Drivers and Pressures Identification and Assessment Report

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Project Acronym	SASPAS
Project ID Number	10048261
Project Title	SAFE ANCHORING AND SEAGRASS PROTECTION IN THE ADRIATIC AREA
Priority Axis	3 - Major change Environment and cultural heritage
Specific objective	3.2 - Contribute to protect and restore biodiversity
Work Package Number	3
Work Package Title	Integrate real-time monitoring system of marine seagrasses (Phanerogamae) in the involved N2K sites
Activity Number	3.2
Activity Title	Drivers and Pressures Identification and Assessment
Partner in Charge	PP1 - SELC Soc. Coop.
Partners involved	ALL PPs
Status	Final
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Summary

Abstract

This document describes the activities planned and carried out in activity 3.2 (Drivers and Pressures Identification and Assessment), reporting the data analysis results.

This analysis shows that there are quite different realities in terms of pleasure yachting and of density of anchorings in the investigated sites of Adriatic coasts and that the impacts on marine seagrasses come from numerous directions. On the basis of the data and information collected and of a conceptual analysis, it is clear that only in some coastal environments the anchorage disturbance causes significant and lasting impacts

1. Introduction

1.1. Aim and objectives

SASPAS (Safe Anchoring and Seagrass Protection in the Adriatic Sea) is a project financed by the INTERREG Italy-Croatia Cross Border Cooperation Programme that aims to provide a proposal to develop and share actions and advanced policies for the conservation and sustainable use of the territory.

The common challenge of Project SASPAS is to preserve and get a better status of conservation of biodiversity of the Adriatic Sea ecosystem in order to decrease its vulnerability.

The overall objective is to improve marine seagrass preservation and restoration through laying safe anchorage systems, performing pilot transplantations, carrying out monitoring activities and by defining an integrated management system for marine seagrasses in Adriatic area. The change will result in an increased level of conservation status of habitat types and species in the involved Natura 2000 sites of the Project areas. To reach the foreseen change the project will take a scientific- applied approach, following the DPSIR (Driving force – Pressure – State – Impact - Response) causal framework, analyzing the interactions between society and the environment - the cause-effect relationships between interacting components of complex social, economic, and environmental systems. Doing so is possible to measure the effectiveness of responses put into place.

Since marine seagrasses and especially *Posidonia oceanica* beds (1120*) are widespread along coastal areas of Interreg Programme and their conservation status is similar in the two Member States, significant results can be achieved only by setting up a good cross-border cooperation within the Italian and Croatian key partners. The cross-border approach ensures coordinated and cooperative actions in planning and performing the protection and restoration activities, as well in developing the foreseen Marine Seagrass Safeguard Integrated Management Program (i.e., the proposed guidelines for the management and right behavior in protected areas). The innovative aspect that goes beyond the existing practices consists in joint cross-border biodiversity protection and restoration through the development of specifically-tailored innovative solutions, harmonized for the Adriatic area and applicable to other similar realities facing with the same biodiversity protection and restoration issues.

The project activities will be carried out within the three project study sites (Figure 1):

1) Monfalcone (Bay of Panzano)
2) Kornati National Park (Nacionalni Park Kornati)
3) Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo.

This proposal is well suited to the Adriatic, in particular to the Apulia (Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo) and Kornati National Park, characterized by widespread coverage of *P. oceanica* (Linnaeus) Delile 1813. In both sites, in summer, there is a notable flow of pleasure boat, and the development of the industry tourism cannot fail to come to terms with the need to preserve the quality of the territory, understood as a whole between land, coast and sea. In Monfalcone (Bay of

Panzano), there is an important coverage of marine seagrasses (i.e. *Cymodocea nodosa* (Ucria) Ascherson 1870) too.

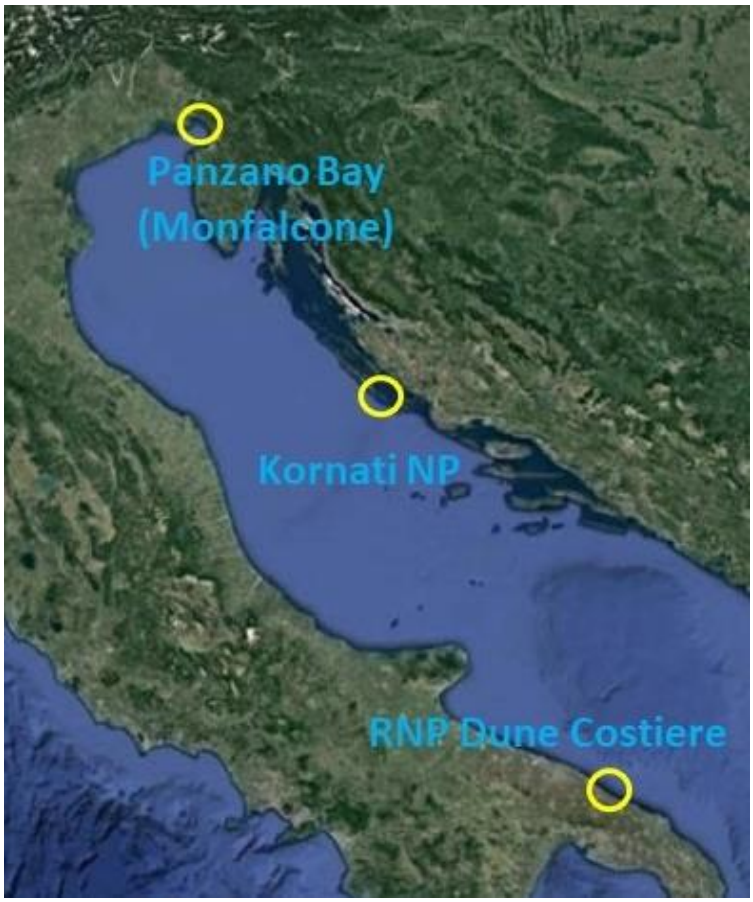

Figure 1. Location of the three project sites.

Both *P. oceanica* and *C. nodosa* play a crucial role in consolidating coastal sediments, slowing down erosive phenomena, thanks to their radical apparatus with which they anchor to the bottom; with the leaf they promote the capture of suspended sediments, helping to limit turbidity, not to mention a series of advantages for marine and lagoon organisms.

The main outputs of the project referred to the foreseen activities are:

- monitoring system with 2 data collections/monitoring campaigns (1 per year),
- placement of environmentally friendly anchoring systems (anchorages and simple signaling buoys),
- pilot transplantations of seagrasses,
- Integrated Management System for seagrasses in the Adriatic area, made by a GIS Digital Information Platform (DIP) and a Marine Seagrass Safeguard Integrated Management Program

(MSSIMP).

Managers of protected areas, local, regional, and national public bodies, environmental associations and NGOs, as well as general public will mostly benefit from project activities.

1.2. Structure of Work Package 3

The objective of the Work Package 3 - *Integrated real-time monitoring system of marine seagrasses (phanerogamae) - in the involved Natura 2000 sites* – is to monitor and gather data on marine seagrasses in the three project sites, in order to improve the protection and to restore the biodiversity in the cross-border area.

The WP3 package consists of three activities:

- activity 3.1 - Preliminary Environmental Survey,
- activity 3.2 - Drivers and Pressures Identification and Assessment,
- activity 3.3 - Monitoring campaigns.

The preliminary survey has the purpose of characterizing the biodiversity of the project sites and gathering up-to-date information on the distribution and quality of seagrasses and their associated biota. The information gathered, will provide a starting point for an analysis of existing drivers and pressures, following the DPSIR (Drivers-Pressure-State-Impact-Response) procedures. Annual monitoring campaigns will be carried out to control the plants phenological life cycle and the spatial dynamics of marine seagrasses as a response to the concrete actions. Moreover, they will help to identify the potential impacts that the project could have on seagrasses meadows and other valuable habitat and species.

The analyses will include all monitoring data, especially those concerning the retreat or surface increase dynamics that will be related to the behavior of biodiversity at eco-friendly buoys.

Thus, the aim is to characterize and quantify, in time and space, the impacts measured and evaluate the biodiversity trends, as much is possible in the time frame of the Project. The results are fundamental to activate or strength different types of protection policies, to act with additional conservation measures or to differently manage recreational boat areas.

This document describes the activities planned and carried out in activity 3.2 (Drivers and Pressures Identification and Assessment), reporting the data analysis results.

2. THE THREE PROJECT AREAS AND THE NATURA 2000 SITES.

2.1. Monfalcone (Bay of Panzano)

The Bay of Panzano is a small bay of the Adriatic Sea (Friuli-Venezia Giulia), located in the northern part of the Gulf of Trieste, limited to the south-west by the Punta Sdobba, at the mouth of the Isonzo River. Inside the Bay of Panzano are located two Natura 2000 sites: a Special Areas of Conservation (SAC) “Cavana di Monfalcone”, a Special Areas of Conservation (SAC) and Special Protection Area (SPA) “Foce dell’Isonzo - Isola della Cona” (Mouth of the Isonzo River and Cona Island) (Figure 2).

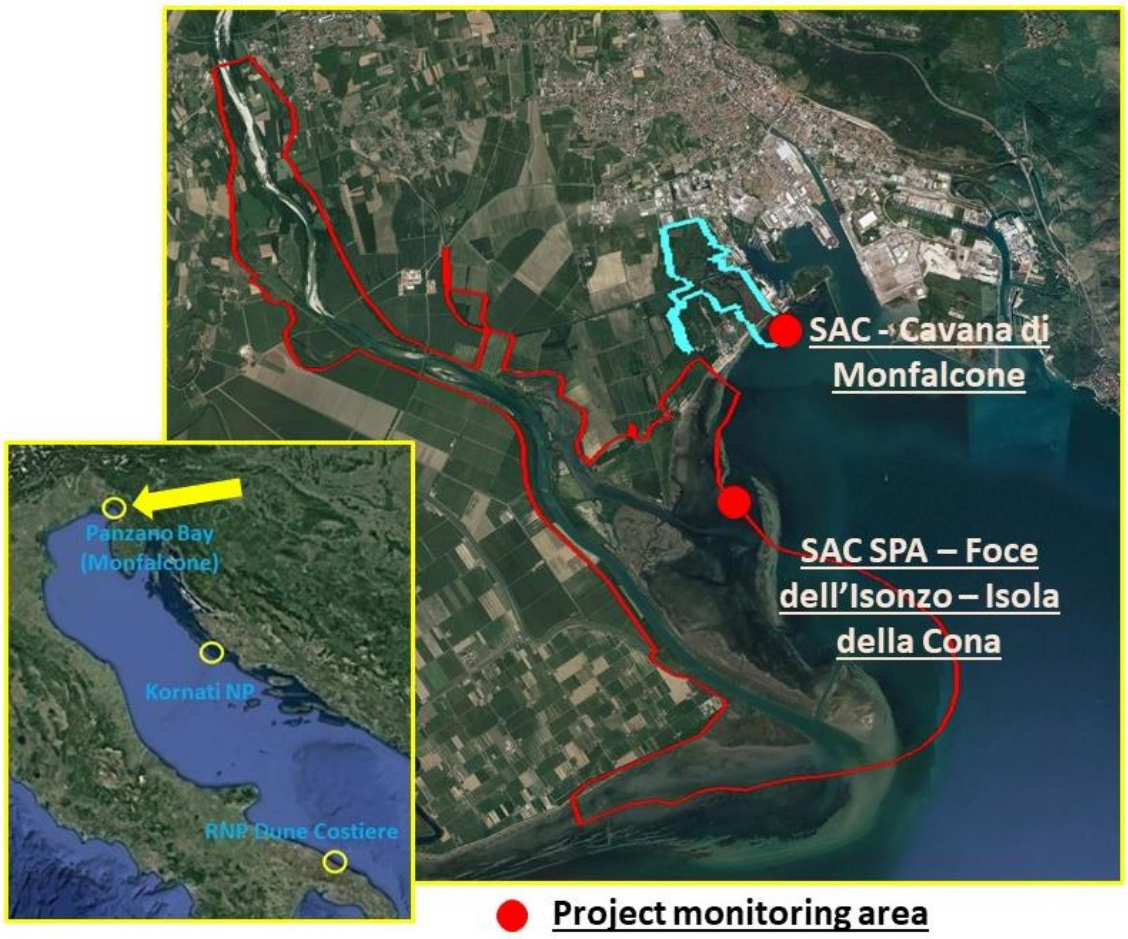

Figure 2. Location of the study areas in the Bay of Panzano, positioned in two Natura 2000 sites.

Natura 2000 site: SAC IT3330007 - Cavana di Monfalcone

The SAC "Cavana di Monfalcone" extends over a surface of 133 ha, 12% out of which are marine, in the transition area between the flat land and the Adriatic Sea and it is important because it includes a set of ecological systems characterized by rare habitats in a good state of conservation. A complex system of spring canals is still present, not modified by the land reclamation. It is a site that includes the ecological spring system closest to the coastline and therefore in direct contact with salty and marine waters. The aquatic surfaces with different state of trophy, water speed, depth and salinity preserve a rich and well-diversified aquatic vegetation. The site extends over a surface of 133 ha, approximately 12 within marine areas.

In the marine area of the site the habitat 1110 is present ("*Sandbanks which are slightly covered by sea water all the time*"). It consists mainly of sandy sediments (larger grain sizes, including boulders and cobbles, or smaller grain sizes including mud may also be present). These habitats are permanently submerged and predominantly surrounded by deeper water. Above the sand-bank the water depth is seldom more than 20 m. In these sub-littoral sandbanks, seagrass meadows can be present: *Zostera marina* (in brackish-salt waters), *Cymodocea nodosa* (in saltwaters) and *Zostera noltei* in shallower salt waters.

The other Habitat identified is the 1140 ("*Mudflats and sandflats not covered by sea water at low tide*") and it is characterized by sands and mud emerging during the low tides, partially covered by *Zostera noltii* and partly coated by green, blue, brown algae and diatoms.

Natura 2000 site: SAC SPA IT3330005 - Foce dell'Isonzo - Isola della Cona

The *SAC SPA* "Foce dell'Isonzo – Isola della Cona" extends over a surface of 2.668 ha, 40% out of which marine. It is situated in the eastern side of the region Friuli Venezia Giulia along the last stretch of the Isonzo River and it largely coincides with the "Foce dell'Isonzo Regional Nature Reserve".

The marine part of the site covers about 1.100 ha of shallow waters with relevant extensions of seagrass meadows; in the marine part of the site the Habitat 1110 ("*Sandbanks which are slightly covered by sea water all the time*") and the Habitat 1140 ("*Mudflats and sandflats not covered by sea water at low tide*") are present.

In the Natura 2000 data forms regarding the sites (http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=IT3330005 – IT3330007), habitat 1110 covers an area of 13 ha and habitat 1140 an area of 3 ha. For both habitats, the data quality has to be considered "Good" (e.g., based on surveys). The degree of representativity of the habitat type on the site (a measure of 'how typical' a habitat type is) is evaluated as "excellent"; their conservation of the structure and functions, and the global assessment of the value of the site for conservation of the natural habitat are considered "Good". For both habitats, the relative surface (Area of the site covered by the natural habitat type in relation to the total area covered by that natural habitat type within the national territory) is reported to be less than 2%.

2.2. Regional Natural Park of Coastal Dunes from Torre Canne to Torre San Leonardo

The “Regional Nature Park Dune Costiere from Torre Canne to Torre San Leonardo” extends over 1.100 ha, along 8 km of coast from the Municipalities of Fasano to Ostuni, and it includes the inland agricultural areas occupied by centuries-old olive groves and ancient “masserie” (typical Apulian farms) (Figure 3). The perimeter follows the long course of the “lame” (55 km of erosion) which characterizes the Park's territorial morphology; they are linear clefts of the land perpendicular to the coastline, with flat bottom and slightly sloping sides originated by the erosive action of the surface water.

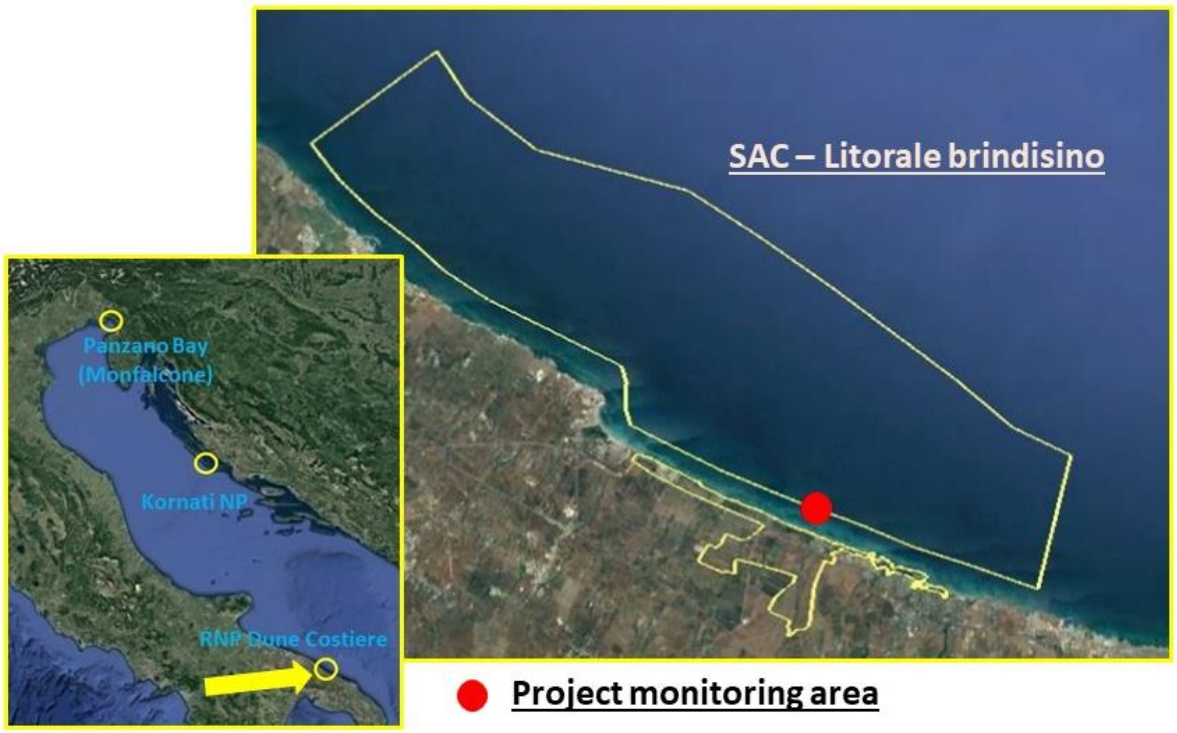

Figure 3. Location of the study area in the RNP Dune Costiere, positioned in a Natura 2000 site.

In the protected area, there are many habitats. Some of those habitats are considered as priority ones, such the *Posidonia oceanica*. Starting at a depth of about 10 m, *P. oceanica* meadows are present on *matte* structures.

The site includes, on the land, a narrow coastal strip with low cliff areas, some retrodunal wetlands (Fiume Grande, Fiume Piccolo, Fiume Morello), a long dune cordon with both herbaceous vegetation and juniper.

The park includes the Special Areas of Conservation (SAC) “Litorale brindisino”.

Natura 2000 site: SAC IT9140002 - Litorale brindisino

The SAC "Litorale brindisino" extends over a surface of 7.256 ha, 95% out of which is marine. The priority habitat 1120* (P. *oceanica*) affects 50% of its total area. It is also characterized by the presence of inland wetlands, where rare or endangered migratory bird species stop or reproduce.

In the marine area of the site the habitat 1110 is present ("*Sandbanks which are slightly covered by sea water all the time*"). It consists mainly of sandy sediments. Medium to coarse grain sizes, also including boulders and cobbles; smaller grain size sediment, including mud may, is also present.

With reference to the SAC area, the official perimeter of the Park immediately distinguishes the coastal territorial area from that of the hinterland, using the S.S. 379 road as a solution of continuity between two different zonings:

1) one of greater naturalistic value: wetlands (Large river, Small river and Morello river), behind the coastal dune cord;

2) one of naturalistic value but characterized by the "natural corridors" of the "Lame".

Regarding the bioclimatic point of view, the area of the Park falls within the Mediterranean macrobioclimate and the lower Mediterranean medium thermotype. The prevailing winds in the Park area are those coming from the North - West, North and North - East, compared to those of southern origin. The average speed values range between 2 and 2.5 m/sec and on some days of the year values of 6 m/sec are reached with Scirocco winds.

In the Natura 2000 data form regarding the site (http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=IT9140002), *P. oceanica* meadows (habitat 1120*) cover an area of 3.628 ha. The degree of representativity of the habitat type on the site (a measure of "how typical" a habitat type is), its conservation of the structure and functions, and its global assessment of the value of the site for conservation of the natural habitat are considered "excellent". The relative surface (Area of the site covered by the natural habitat type in relation to the total area covered by that natural habitat type within the national territory) is reported to be less than 2%.

2.3. Kornati NP

The Kornati National Park is designated as Site of Community Importance SCI HR4000001 - Nacionalni Park Kornati (Figure 4). The park[1] was established in 1980 and its management started in 1982. It currently comprises 89 islands and reefs, a total area of 217 km², from which almost 80% is marine territory (Land 50 km² / Sea 167 km²) and a total coastline of 238 km. Karst features dominate its geomorphology. It is estimated that at least 2.500 to 3.000 families of benthic and pelagic fauna live in the Kornati archipelago: 353 species of algae, 3 species of underwater flower plants as well as about 850 animal species – 61 species of corals, 177 species of molluscs, 127 species of polychaetes, 61 species of decapod crabs, 64 species of echinoderms and 185 species of fishes.

Meadows of *P. oceanica* are also present in the Park, up to depths of 25-30 meters. In the Natura 2000 data form regarding the park[2], *P. oceanica* meadows (habitat 1120*) cover an area of 2100 ha, but the data quality has to be considered "poor" (e.g., rough estimation). The degree of representativity of the habitat type on the site (a measure of 'how typical' a habitat type is), its conservation of the structure and functions, and its global assessment of the value of the site for conservation of the natural habitat are considered "good". The relative surface (Area of the site covered by the natural habitat type in relation to the total area covered by that natural habitat type within the national territory) is reported to be less than 2%.

The marine invasive species marine invasive species *Caulerpa cylindracea*[3] (a green alga) and *Womersleyella setacea* (a red alga that grows over *Posidonia oceanica* rhizomes) have been observed in the last years and is spreading in the entire Park.

A public institution, under the competence of the Ministry of Environment and Energy, manages the Kornati National Park. The terrestrial part of the park is entirely under private ownership (around 620 owners).

There are four no-take zones where only scientific research is allowed. Sailing is allowed in the whole of the Kornati National Park except in the zones of strict protection. Anchoring and overnighting are permitted only at 19 locations (bays and coves[4]). Autonomous diving is allowed only in organized groups, with an axpensive license for autonomous diving in the Kornati NP obtained in advance. A limited number of authorized private diving organizations, at cheaper costs, take divers to the sea in some permitted

[1] The data cited in the following paragraphs are reported in the articles: Casier R., 2011; Garrabou et al., 2014; Ivković N., 2015; Mihelcic and Ramov, 2018;).

[2] (http://natura2000.dzzp.hr/reportpublish/ reportproxy.aspx?paramSITECODE=HR4000001)

[3] Caulerpa cylindracea Sonder [previously known as Caulerpa racemosa var. cylindracea (Sonder) Verlaque, Huisman et Boudouresque]

[4] Anchorage and overnight stays are permitted in the following inlets: Stiniva, Stival, Tomasovac – Suha punta, Šipnate, Lučica, Kravljačica, Strižnja, Vrulje, Gujak, Opat, Smokvica, Ravni Žakan, Lavsa, Piškera – Vela Panitula and at Anica cove on Levrnaci, Podbižanj and Koromašna.

locations[5]. Diving visits using scuba diving gear may only be conducted on organised and approved groups and exclusively under the organisation of legal entities and/or natural persons registered for the performance of these activities and that conclude an agreement with the Kornati National Park Public Institution on the organisation and operating of diving visits in Kornati National Park.

Since 2013, traditional fishing in Kornati National Park is forbidden and only recreational fishing is allowed.

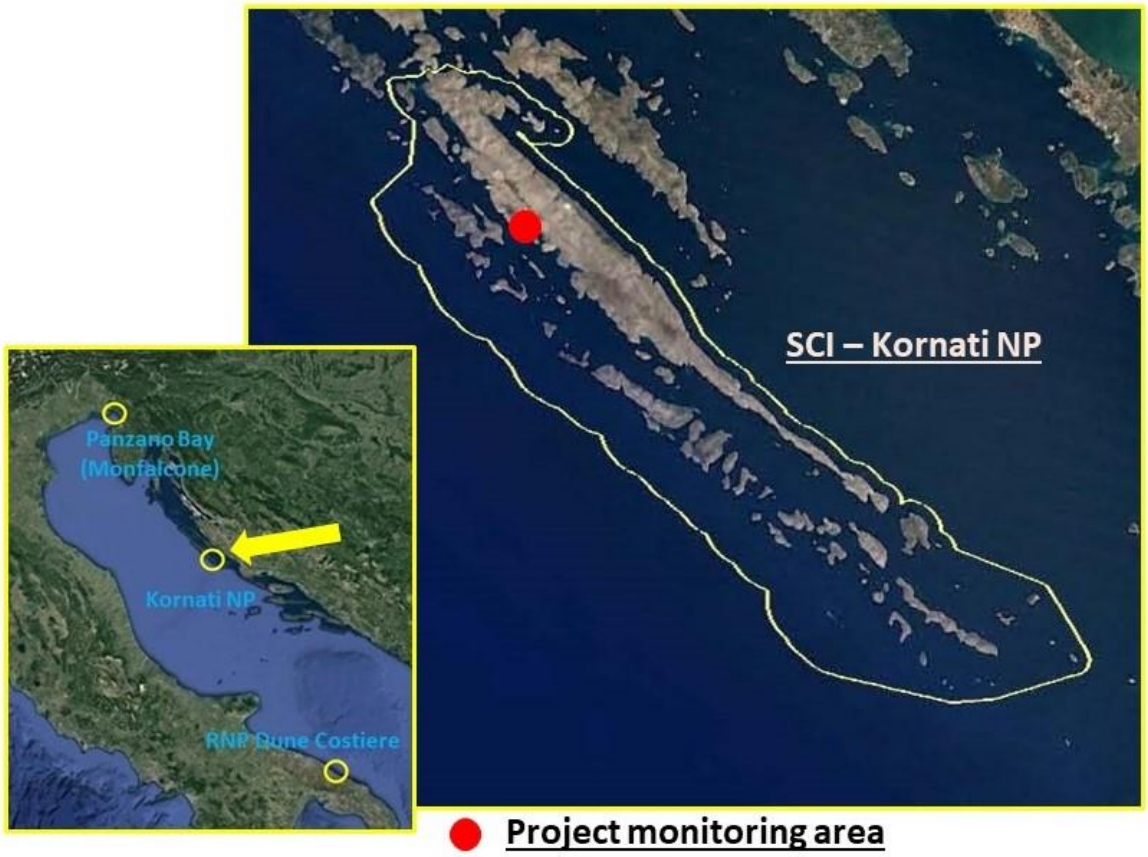

Figure 4. Location of the study area in the Natura 2000 site Kornati NP.

[5] There are nine zones in which diving visits are permitted in Kornati National Park: Kornat (Opat – Tanka Prisliga), Samograd, Oključ, Mala Panitula, Vela Panitula, Rašip, Kasela, Mana and Borovnik.

3. DPSIR FRAMEWORK

The second activity planned in the WP3 is the application of the DPSIR (Driver-Pressure-State-Impact-Response) framework (model) to the three study areas, to identify the main Drivers, Pressures, States and Impacts to seagrass meadows, water column, benthic communities, and the bivalve *Pinna nobilis* (Linnaeus, 1758).

The DPSIR is the causal framework for describing the interactions between society and the environment developed by the European Environment Agency (EEA) and adopted as the most appropriate way to structure environmental information by most Member States of the European Union and by international organizations dealing with environmental information and reporting.

The application of the DPSIR framework will structure all the collected data from the point of view of a causal chain, from driving forces to impacts (and possible responses).

The DPSIR framework consists of 5 elements linked together by one causal chain (Figure 5): **D**riving forces, **P**ressures, **I**mpacts, **R**esponses.

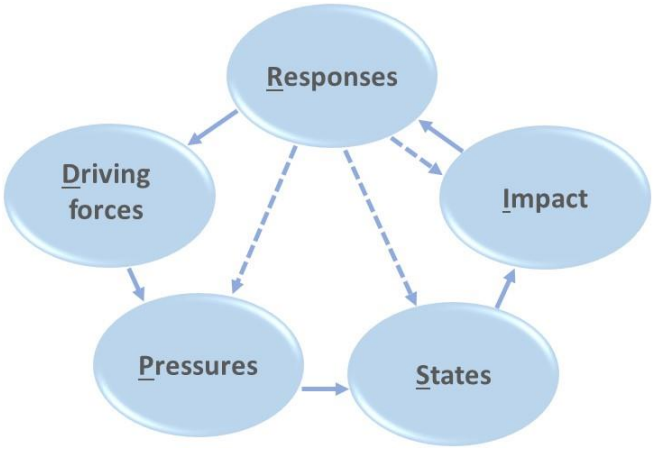

Figure 5. DPSIR analysis scheme.

Driving force (or driver): it is a human activity, in particular production and consumption processes, that may produce an environmental effect (i.e., a pressure) on the ecosystem (primary causes of alteration of environment's quality). They are the factors that motivate human activities and fulfill basic human needs for food and raw materials, water, culture, security, health, shelter, and infrastructure: agriculture, aquaculture, fishing, transport, tourism, and recreation.

Pressure: it is a mechanism through which a Driver has an effect on the environment and can be of a physical, chemical, or biological nature, including for example the emissions of chemicals or waste, or the introduction of invasive alien species.

State: it is the quality of the abiotic (water, soil) and biotic (benthos, seagrasses) components of the ecosystems in terms of physical, chemical, and biological conditions. State refers to the environmental

condition of an ecosystem as described by its physical, chemical, and biological parameters.

Impact: it refers to the "changes" in the physical, chemical, or biological state of the environment determine the quality of ecosystems and the welfare of human beings. Changes in the *State* may have environmental or economic 'impacts' on the functioning of ecosystems, their life supporting abilities, and ultimately on human health and on the economic and social performance of society. Impacts can be defined as consequences of environmental state change in terms of substantial environmental and/or socio-economic effects that can be positive or negative.

Response: it can be defined as all management actions seeking to reduce or prevent an unwanted change or to develop a positive (desirable) change in the ecosystem.

The *Driving forces* (e.g., transport) create *Pressures* (e.g., recreational piers, polluting emissions) that affect the *State* of environmental compartments (e.g., water quality, seagrass meadows). Changes in the *State* may generate *Impact* on the functioning of ecosystems (e.g., biodiversity loss) making it necessary to find Responses (e.g., environmental management strategies). The *Responses* can affect any part of the chain between driving forces and impacts: regulation of Driving Forces, reduction of Pressures, improving the State and mitigation of Impact.

4. DPSIR ANALYSIS APPLIED TO PROJECT SITES: RESULTS AND DISCUSSION

4.1. The application of the conceptual framework to SASPAS

The application of DPSIR framework in SASPAS is necessary to characterize and quantify the impacts and evaluate how marine seagrass can absorb them or how much they can be affected and consequently decline. Also impacts on seagrass meadows, water column, benthic communities, and the bivalve *Pinna nobilis,* will be evaluated.

In the DPSIR literature, the State may refer either to natural systems alone or to both natural and socio-economic systems (Maxim *et al*., 2009). Depending on the system chosen for the analysis the notion of Impact may focus on completely different target points.

Within SASPAS project, the DPSIR framework has been applied to biodiversity issues, so only the State of the environmental compartments and the Impacts on the related ecosystems and their functioning has been considered (impacts on health and social and economic issues has not been considered).

All the information concerning use, pressures (marine traffic, leisure boat traffic and anchoring, amateur fish, diving, etc.) and possible impacts were gathered in order to compose a conceptual framework, useful to evaluate the functionality and effectiveness of the project concrete actions and the response of environment.

A list of possible relevant drivers and pressures was prepared (Table 1). With the collaboration and contribution of the project partners, three tables to link these drivers and pressures to the states have been completed to do a qualitative analysis for each site (Tables 2, 3 and 4).

The subsequent step was the collection of quantitative data (quantitative analsysis) and the selection of the main indicators to turn these data into relevant information (paragraph 4.2).

Driving forces

- D - Transportation and service corridors: this kind of driver induces pressures such as long narrow transport corridors and the vehicles that use them, and wildlife mortality (accidental mortalities and habitat loss and fragmentation). The pressures are associated with the quantity and location of transportation and service networks, including boats (this includes direct discharge and damage from wakes and anchors from non-recreational vessels, including commercial transport and tourist ships in freshwater and marine waterways).

- F - Biological resource use other than agriculture & forestry: this kind of driver (Marine and Freshwater Aquaculture and fishing) induces pressures such as overharvesting of biological resources for commercial, recreational, food gathering, research, or cultural purposes; including both deliberate and unintentional harvesting beyond sustainable levels (harvesting aquatic resources - wild and cultivated species - at levels that are not sustainable).

- G - Human intrusions and disturbances: this kind of driver induces pressures from human activities that alter, destroy, and disturb habitats and species associated with non-consumptive uses of biological resources. For examples, boats and boating activities in areas that are not normally used as transportation corridors can cause direct mortality of aquatic species. This includes recreational vessels and associated air and water pollution.

- H - Pollution: this kind of driver induces pressures from introduction of exotic and/or excess materials (liquid. gas, solid) or energy from point and nonpoint sources.

- I - Invasive, other problematic species and genes: this kind of driver induces pressures from introductions that can have harmful effects on biodiversity following their establishment, spread and/or increase in abundance. Invasive species, which are plants and animals that are not native to an ecosystem, are capable of aggressively establishing or causing environmental damage by compete with native species for resources, such as food, and have no natural predators to restrict their ability to breed and thrive. Invasive species may force out or cause native species to become extinct.

- J - Natural system modifications: this kind of driver induces pressures from actions that convert or degrade habitat in the course of "managing" natural or semi-natural systems, often to improve human welfare. For examples, pressures from armoring of marine shorelines and overwater structures that alter, destroy, and disturb habitats and species via a non-consumptive use, including industrial, commercial, and recreational marinas, ports and shipyards.

- K - Natural biotic and abiotic processes (without catastrophes): change (in the form of both abiotic and biotic factors) is a fundamental factor in determining whether a plant or animal species survives, moves out of an environment, or goes extinct. Abiotic factors include all non-living items within an ecosystem, such as temperature and rainfall. Biotic factors are all the living organisms within an ecosystem. Unfavorable abiotic or biotic factors may have dire consequences for a species.

Pressures

The reference list on pressures has been elaborated by the Directorate-General for Environment (the European Commission department responsible for EU policy) and the European Environment Agency (EEA). It is the same code list used for the reporting of impacts and activities under Article 17 of the Habitats Directive and it can be found in the "Reference Portal for Natura 2000" (http://cdr.eionet.europa.eu/help/natura2000). The possible pressures for each driver that have been considered in SASPAS are listed below:

- D - Transportation and service corridors:
  - D03 shipping lanes, ports, marine constructions.

- F - Biological resource use other than agriculture & forestry:
  - F01 marine and freshwater aquaculture,

  - F02 fishing and harvesting aquatic resources.

- G - Human intrusions and disturbances:
  - G01 outdoor sports and leisure activities, recreational activities,
  - G05 other human intrusions and disturbances.

- H - Pollution:
  - H01 pollution to surface waters (limnic, terrestrial, marine & brackish),
  - H03 marine water pollution.

- I - Invasive, other problematic species and genes:
  - I01 invasive non-native species.

- J - Natural system modifications:
  - J02 human induced changes in hydraulic conditions,
  - J03 other ecosystem modifications.

- K - Natural biotic and abiotic processes (without catastrophes):
  - K01 abiotic (slow) natural processes,
  - K02 Biocenotic evolution, succession
  - K03 interspecific faunal relations,
  - K04 interspecific floral relations.

States

As a result of pressures, the "state" of the environment, the quality of the various environmental compartments (such as air, water, soil, etc.), can be affected. In the three study sites, the impacted states that have been considered are:

- quality of water column;
- seagrass meadows;
- associated benthic communities;
- the bivalve *Pinna nobilis* (in annex 4 of Habitat Directive).

Impacts

The main environmental potential impacts that have been considered are listed below:

Environmental impacts:

- degradation of marine seagrass health, rise of compensation point depth, as an increase in turbidity;
- rise of sedimentation on leaves, possible suffocation, and reduction in density as a result of

sediment resuspension due to frequent anchoring operations;
- eutrophication of the most sheltered sites as a result of domestic discharged sewage;
- physical disturbance due to fishing and aquaculture operations (eradication, plant rarefaction);
- rarefaction of *Pinna nobilis* individuals (habitat and species degradation);
- litter accumulation (suffocation, habitat, and species degradation).

Ecological impacts:

- loss of biodiversity,
- effects due to increase of invasive species,
- loss of ecosystem services.

These impacts, from an ecological point of view, are an integrated result of the suffering conditions that directly or indirectly affect marine seagrasses and the species connected to their habitat. For this reason, they are only considered as actions in being, because they cannot be fully addressed in this WP activity.

Some impacts above listed are precisely subject to verification in the context of the monitoring program by the Project, such as the quality controls provided for *P. oceanica* and *C. nodosa* meadows or those for the control of *P. nobilis* and the presence of litters on the seabed. These parameters will also permit the evaluation, at the ecological response level, of any falls in biodiversity due, for example, to the excessive anchoring and exploitation of the most valuable sites in the Project areas.

It is important to specify that, due to the project time and scheduling, some parameters such as the sedimentation and resuspension level or the eutrophication level of the different sites will be only partially examined.

Responses

The management actions that aim to reduce or prevent an unwanted change or to develop a positive (desirable) change in the ecosystem are:

- monitoring,
- aquaculture and fishing regulation,
- discharge regulation,
- policy (MSP, ICZM, N2000 sites management plans).

SASPAS responses with WP5 Activity 2:

- anchoring regulation,
- tourism and water traffic regulation,
- public awareness and communication.

Possible responses to specific criticalities highlighted for each project site are discussed in the paragraph 4.5.4.

4.2. Qualitative analysis

As mentioned before, a list of possible relevant drivers and pressures was prepared (Table 1). For each site, a table to link these drivers and pressures to the states has been completed (Tables 2, 3 and 4).

Table 1. List of possible drivers and pressures.

DRIVERS	PRESSURES
TRANSPORTATION AND SERVICE CORRIDORS	***D03 shipping lanes, ports, marine constructions***
	D03.01 port areas
	D03.01.02 piers/tourist harbours or recreational piers
BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY	***F01 marine and Freshwater Aquaculture***
	F01.01 intensive fish farming, intensification
	F01.02 suspension culture
	F02 fishing and harvesting aquatic ressources
	F02.01 Professional passive fishing
	F02.01.01 potting
	F02.01.02 netting
	F02.01.03 demersal longlining
	F02.01.04 pelagic longlining
	F02.02 professional active fishing
	F02.02.02 pelagic trawling
	F02.02.03 demersal seining
	F02.02.04 purse seining
	F02.02.05 benthic dredging
	F02.03 leisure fishing
	F02.03.02 pole fishing
	F02.03.03 spear-fishing
HUMAN INTRUSIONS AND DISTURBANCES	***G01 outdoor sports and leisure activities, recreational activities***
	G01.01 nautical sports
	G01.01.01 motorized nautical sports
	G01.01.02 non-motorized nautical sports
	G01.07 scubadiving, snorkeling
	G05 Other human intrusions and disturbances
	G05.02 shallow surface abrasion/ mechanical damage to seabed surface
	G05.03 penetration/disturbance belowsurface of the seabed
POLLUTION	***H01 pollution to surface waters (limnic, terrestrial, marine & brackish)***
	H01.08 diffuse pollution to surface waters due to household sewage and
	H03 marine water pollution
	H03.01 oil spills in the sea
	H03.02 toxic chemical dischargefrom material dumped at sea
	H03.02.01 non-synthetic compound contamination
	H03.02.02 synthetic compound contamination
	H03.02.04 introduction of other substance (e.g. liquid, gas)
	H03.03 marine macro-pollution (i.e. plastic bags, styrofoam)
INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES	***I01 invasive non-native species***
NATURAL SYSTEM MODIFICATIONS	***J02 human induced changes in hydraulic conditions***
	J02.12 dykes, embankments, artificial beaches, general
	J02.12.01 Sea defense or coast protection works, tidal barrages
NATURAL BIOTIC AND ABIOTIC PROCESSES (WITHOUT CATASTROPHES)	***K01 abiotic (slow) natural processes***
	K01.01 erosion
	K01.02 silting up
	K02 biocenotic evolution, succession
	K02.01 species composition change (succession)
	K02.02 accumulation of organic material
	K02.03 eutrophication (natural)
	K03 interspecific faunal relations
	K03.03 introduction of deisease (microbial pathogens)
	K04 interspecific floral relations
	K04.01 competition
	K04.02 parasitism
	K04.03 introduction of disease (microbial pathogens)
	K04.05 damage by herbivores (including game species)

4.2.1. Qualitative analysis for Monfalcone (Bay of Panzano) site

In the table 2, the list of possible relevant drivers and pressures identified in table 1 was applied to Monfalcone (Bay of Panzano) site, linking them to the states; in the figure 6, the DPSIR conceptual scheme (identified in table 2) related to driving forces - pressures - states for Monfalcone (Bay of Panzano) site is reported.

Table 2. Monfalcone (Bay of Panzano): list of possible drivers and pressures.

MONFALCONE (Bay of Panzano)					
DRIVERS	**PRESSURES**	**STATE**			
		Water column	Seagrass meadows	*Pinna nobilis*	Benthos
TRANSPORTATION AND SERVICE CORRIDORS	***D03 shipping lanes, ports, marine constructions***				
	D03.01 port areas				
	D03.01.02 piers/tourist harbours or recreational piers	X	X	X	X
BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY	***F01 marine and Freshwater Aquaculture***				
	F01.01 intensive fish farming, intensification			X	X
	F01.02 suspension culture	X	X	X	X
	F02 fishing and harvesting aquatic ressources				
	F02.03 leisure fishing				
	F02.03.03 spear-fishing		X	X	X
HUMAN INTRUSIONS AND DISTURBANCES	***G01 outdoor sports and leisure activities, recreational activities***				
	G01.07 scubadiving, snorkeling		X	X	X
	G05 other human intrusions and disturbances				
	G05.03 penetration/disturbance belowsurface of the seabed		X	X	X
POLLUTION	***H03 marine water pollution***				
	H03.02 toxicchemical dischargefrom material dumped at sea				
	H03.02.01 non-synthetic compound contamination				X
	H03.02.04 introduction of other substance (e.g. liquid, gas)	X	X	X	X
INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES	***I01 invasive non-native species***	X	X	X	X
NATURAL SYSTEM MODIFICATIONS	***J02 human induced changes in hydraulic conditions***				
	J02.12 dykes, embankments, artificial beaches, general	X	X	X	X
	J02.12.01 sea defense or coast protection works, tidal barrages	X	X	X	X
NATURAL BIOTIC AND ABIOTIC PROCESSES (WITHOUT CATASTROPHES)	***K01 abiotic (slow) natural processes***				
	K01.02 silting up	X	X	X	X
	K02 biocenotic evolution, succession				
	K02.01 species composition change (succession)	X	X	X	X
	K02.02 accumulation of organic material	X	X	X	X
	K02.03 eutrophication (natural)	X	X	X	X
	K03 interspecific faunal relations				
	K03.03 introduction of deisease (microbial pathogens)			X	X
	K04 interspecific floral relations				
	K04.05 damage by herbivores (including game species)		X		X

In the Natura 2000, data form regarding the two Natura 2000 sites “Special Areas of Conservation (SAC) Cavana di Monfalcone” and “Special Areas of Conservation (SAC) and Special Protection Area (SPA) Foce dell’Isonzo - Isola della Cona (Mouth of the Isonzo River and Cona Island) (http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=IT3330005 and IT3330007), other pressures are also reported (such as G01.01 nautical sports for both sites and G01.01 nautical sports, H01 Pollution to surface waters (limnic, terrestrial, marine & brackish) and J02.01.02 reclamation of land from sea, estuary or marsh for “IT3330007 Cavana di Monfalcone”).

In the data form, the following pressures are not listed but they have been considered in this DPSIR analysis report:

- D03.01.02 piers/tourist harbours or recreational piers,
- F01.01 intensive fish farming, intensification,
- F01.02 suspension culture,
- F02.03.03 spearfishing,
- G01.07 scuba diving, snorkelling,
- G05.03 penetration/disturbance below surface of the seabed,
- H03.02 toxichemical discharge from material dumped at sea,
- H03.02.01 non-synthetic compound contamination,
- H03.02.04 introduction of other substance (e.g., liquid, gas),
- J02.12 dykes, embankments, artificial beaches, general,
- J02.12.01 sea defence or coast protection works, tidal barrages,
- K03.03 introduction of diseases (microbial pathogens),
- K04.05 damage by herbivores (including game species).

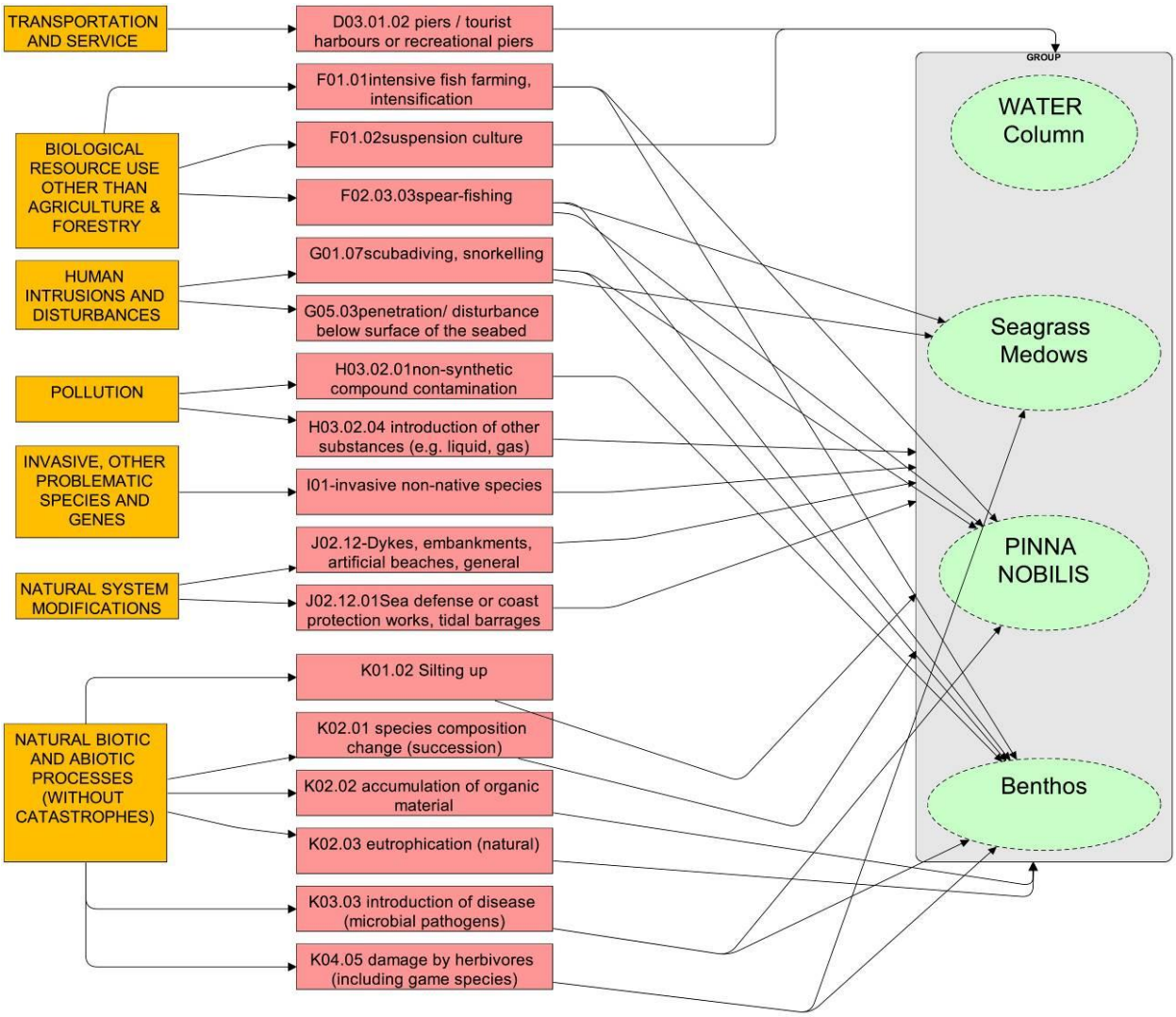

Figure 6. DPSIR conceptual scheme related to driving forces (orange) - pressures (pink) - states (green) for Monfalcone (Bay of Panzano) site.

4.2.2. Qualitative analysis for Kornati NP site

In the table 3, the list of possible relevant drivers and pressures identified in table 1 was applied to Kornati NP site, linking them to the states; in the figure 7, the DPSIR conceptual scheme (identified in table 3) related to driving forces - pressures - states for Kornati NP site is reported.

Table 3. Kornati NP: list of possible drivers and pressures.

KORNATI NP					
DRIVERS	**PRESSURES**	**STATE**			
		Water column	Seagrass meadows	*Pinna nobilis*	Benthos
TRANSPORTATION AND SERVICE CORRIDORS	***D03 shipping lanes, ports, marine constructions***				
	D03.01 port areas				
	D03.01.02 piers / tourist harbours or recreational piers	X	X	X	X
HUMAN INTRUSIONS AND DISTURBANCES	***G01 outdoor sports and leisure activities, recreational activities***				
	G01.01 nautical sports				
	G01.01.01 motorized nautical sports	X	X	X	X
	G01.07 scubadiving, snorkelling			X	X
POLLUTION	***H01 pollution to surface waters (limnic, terrestrial, marine & brackish)***				
	H01.08 diffuse pollution to surface waters due to household sewage and waste waters	X			
	H03 marine water pollution				
	H03.01 oil spills in the sea	X			
	H03.02 toxic chemical discharge from material dumped at sea				
	H03.03 marine macro-pollution (i.e. plastic bags, styrofoam)	X	X		X
INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES	***I01 invasive non-native species***		X		X
NATURAL BIOTIC AND ABIOTIC PROCESSES (WITHOUT CATASTROPHES)	***K02 biocenotic evolution, succession***				
	K02.01 species composition change (succession)				X
	K03 interspecific faunal relations				
	K03.03 introduction of disease (microbial pathogens)			X (*)	
	K04 interspecific floral relations				
	K04.01 competition				X
	K04.05 damage by herbivores (including game species)				X

(*) = possible threath, new mortality spots detected in South Croatia

In the Natura 2000 data form regarding the park (http://natura2000.dzzp.hr/reportpublish/reportproxy.aspx?paramSITECODE=HR4000001), other pressures are also reported (such as H05.01 garbage and solid waste, I02 problematic native species and M01.02 droughts and less precipitations). In the data form, the following pressures are not listed but they have been considered in this DPSIR analysis report:

- H01.08 diffuse pollution to surface waters due to household sewage and waste waters,
- H03.01 oil spills in the sea,
- H03.02 toxic chemical discharge from material dumped at sea,
- K02.01 species composition change (succession),
- K03.03 introduction of disease (microbial pathogens),
- K04.05 damage by herbivores (including game species).

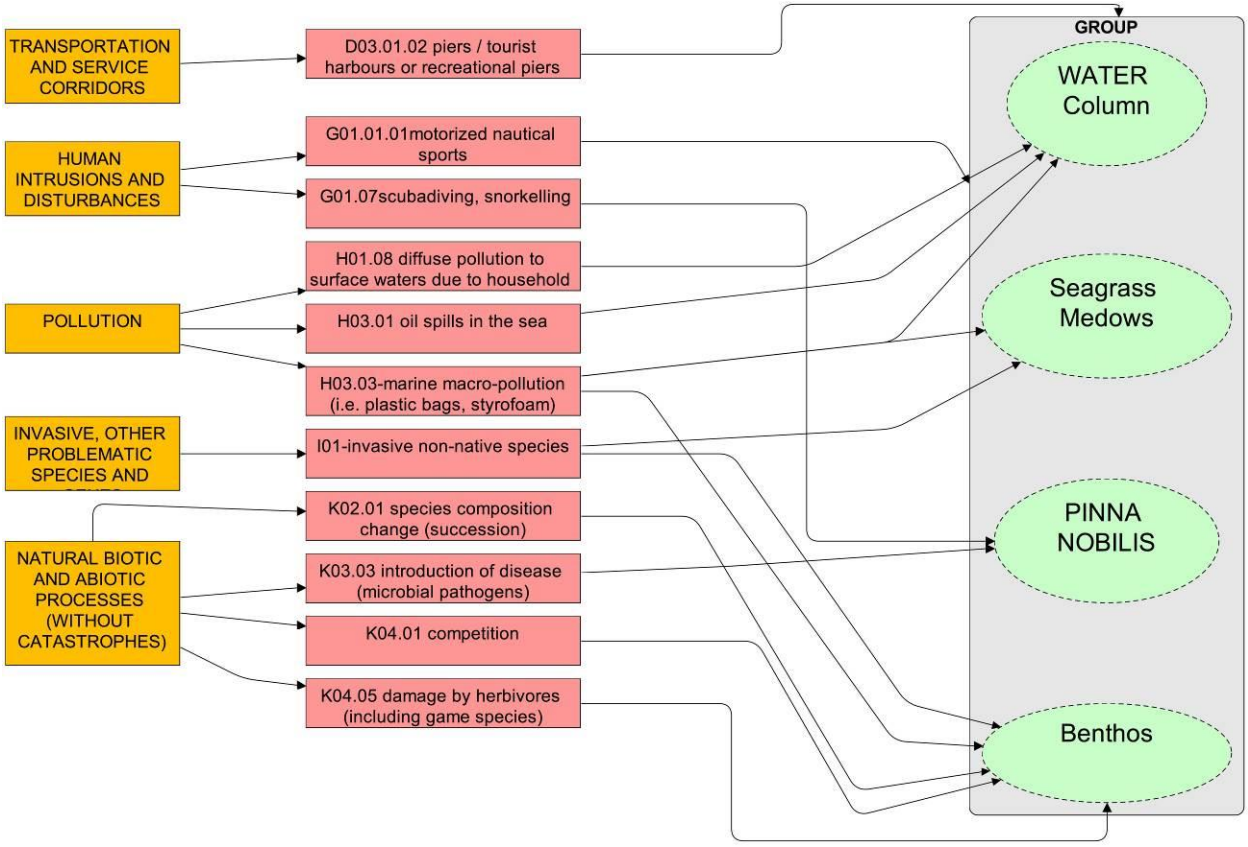

Figure 7. DPSIR conceptual scheme related to driving forces (orange) - pressures (pink) - states (green) for Kornati NP site.

4.2.3. Qualitative analysis for RNP Coastal Dunes site

In the table 4, the list of possible relevant drivers and pressures identified in table 1 was applied to RNP Coastal Dunes site, linking them to the states; in the figure 8, the DPSIR conceptual scheme (identified in table 4) related to driving forces - pressures - states for RNP Coastal Dunes site is reported.

Table 4. RNP Coastal Dunes: list of possible drivers and pressures.

RNP COASTAL DUNES					
DRIVERS	**PRESSURES**	**STATE**			
		Water column	Seagrass meadows	*Pinna nobilis*	Benthos
TRANSPORTATION AND SERVICE CORRIDORS	***D03 shipping lanes, ports, marine constructions***				
	D03.01 port areas				
	D03.01.02 piers / tourist harbours or recreational piers	X	X	X	X
BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY	***F02Fishing and harvesting aquatic resources***				
	F02.01 Professional passive fishing				
	F02.01.01 potting				X
	F02.01.02 netting				X
	F02.01.03 demersal longlining				X
	F02.01.04 pelagic longlining				X
	F02.02 professional active fishing				
	F02.02.02 pelagic trawling	X	X	X	X
	F02.02.03 demersal seining		X		X
	F02.02.04 purse seining	X	X	X	X
	F02.02.05 benthic dredging	X	X	X	X
	F02.03 leisure fishing				
	F02.03.02 pole fishing	X	X	X	X
	F02.03.03 spear-fishing	X	X	X	X
HUMAN INTRUSIONS AND DISTURBANCES	***G01 outdoor sports and leisure activities, recreational activities***				
	G01.01 nautical sports				
	G01.01.01 motorized nautical sports	X	X	X	X
	G01.01.02 non-motorized nautical sports		X	X	X
	G01.07 scubadiving, snorkelling	X	X	X	X
	G05 other human intrusions and disturbances				
	G05.02 shallow surface abrasion/ mechanical damage to seabed surface	X	X	X	X
	G05.03 penetration/ disturbance below surface of the seabed	X	X	X	X
POLLUTION	***H03 marine water pollution***				
	H03.01 oil spills in the sea	X	X		
	H03.02 toxic chemical discharge from material dumped at sea				
	H03.02.01 non-synthetic compound contamination	X		X	X
	H03.02.02 synthetic compound contamination	X		X	X
	H03.03 marine macro-pollution (i.e. plastic bags, styrofoam)	X	X	X	X
INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES	***I01 invasive non-native species***	X	X	X	X
NATURAL BIOTIC AND ABIOTIC PROCESSES (WITHOUT CATASTROPHES)	***K01 abiotic (slow) natural processes***				
	K01.01 erosion	X	X	X	X
	K01.02 silting up	X	X	X	X
	K02 biocenotic evolution, succession				
	K02.01 species composition change (succession)	X	X	X	X
	K02.02 accumulation of organic material		X		
	K02.03 eutrophication (natural)	X		X	X
	K03 interspecific faunal relations				
	K03.03 introduction of disease (microbial pathogens)	X			
	K04 interspecific floral relations				
	K04.01 competition	X	X	X	X
	K04.02 parasitism	X	X	X	X
	K04.03 introduction of disease (microbial pathogens)				X

In the Natura 2000 data form regarding the “Litorale brindisino” http://http://natura2000.eea.europa.eu/Natura2000/ SDF.aspx?site=IT9140002), no pressures are reported.

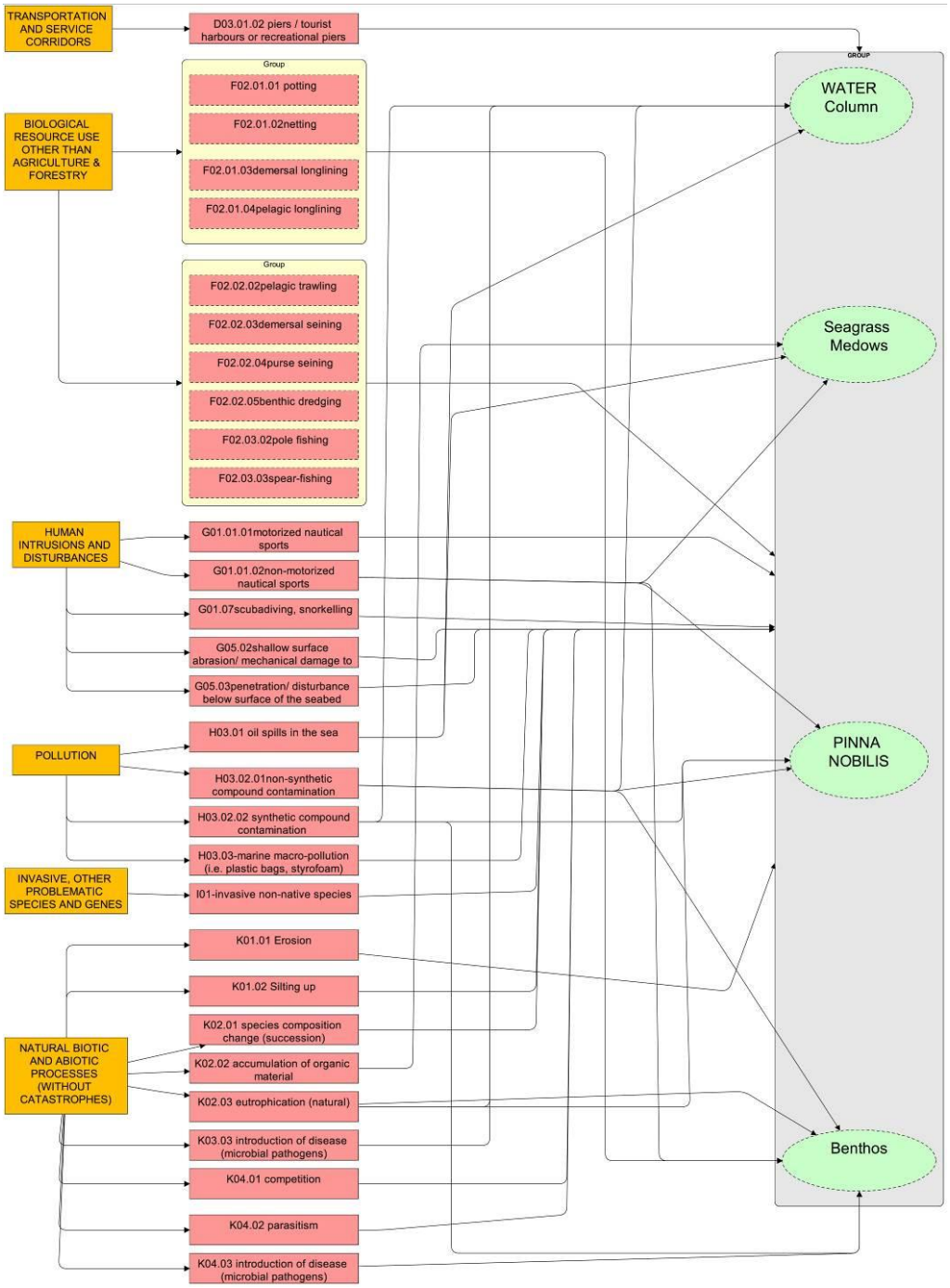

Figure 8. DPSIR conceptual scheme related to driving forces (orange) - pressures (pink) - states (green) for RNP Coastal Dunes site.

4.3. Quantitative analysis

For each project site, the quantitative data collected are summarized in the following paragraphs. The collection of quantitative data is based on different methodologies, such as data recovery from official reports, through webgis services of European projects or interviews with the main professional operators, etc. In this way, for each site, the main pressures up to here highlighted are presented through the most effective indicators and connected to the impacts we have seen and analyzed with the general collection of information.

The table 5 summarizes for each Driver the pressure indicators that have been considered in the analysis and the data availability for each site; the presence of the pressure/indicator is indicated with an X in the table 5. Some pressures are present even if data relating to their indicators are not available; in this case, their presence is indicated by an (X).

Table 5. Driver and Pressure indicators considered in the quantitative analysis and the data availability for each site.

Driver/Pressure indicators	Bay of Panzano (Monfalcone)	Kornati NP	RNP Coastal Dunes
TRANSPORTATION AND SERVICE CORRIDORS			
No. of marinas and main ports	X	X	X
No. of pleasure boats/marina	X	X	X
No. of fishing boats	X	X	X
No. of transits			X
BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY			
No. of aquaculture facilities	X		
Total surface area of the installations	X		
Production of aquaculture farms	X		
No. of fish farms	X		
Surface of the installations	X		
Average production (not yet recovered)	X		
No. of freediving fishermen	X		
Average fishing days	X		
No. of professional fishing boats			X
Mean of working days/year			X
Fishing permits		X	

Driver/Pressure indicators	Bay of Panzano (Monfalcone)	Kornati NP	RNP Coastal Dunes
HUMAN INTRUSIONS AND DISTURBANCES			
No. of diving schools	X	(X)	X
No. of dives	X	(X)	(X)
Anchorage frequency	X	(X)	X
No. of boats	X	X	X
No. of snorkeling service companies		(X)	X
POLLUTION [(1)]			
-	(X)	(X)	(X)
INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES			
Invasive alien species	X	X	X
NATURAL SYSTEM MODIFICATIONS			
Dikes and breakwater	X		X
NATURAL BIOTIC AND ABIOTIC PROCESSES (WITHOUT CATASTROPHES)			
Frontal erosion (shoreline)			X
Microbial pathogens	X	X	X

X = avalaible data / (X) = not avalaible data

[(1)] For the driver pollution, the relative pressure indicators express point values of some parameters that are linked to limited periods of time (for example the concentration of a certain pollutant collected in a monitoring station at a certain time of a day). A single value or the average of some values cannot therefore be directly connected to the pressure acting on the site if not through an expert evaluation (for example through the application of a biological index).

4.3.1. Analysis of collected data for Monfalcone site (Bay of Panzano)

The collection of quantitative data is based on four different methodologies:

1. data recovery from official reports of the main research institutes and monitoring bodies such as the regional environmental protection agency;
2. data recovered through webgis services of European projects such as ADRIPLAN, MedTrends, AdriBlue, EcoSea, etc.;
3. interviews with the main professional operators in the area to retrieve qualitative/quantitative information on activities such as fishing, pleasure boating or sports activities;
4. analysis of GIS data such as satellite images but also free access GeoDB, as the "The European Marine Observation and Data Network" (EMODnet), etc;

Data have been collected and harmonized according to the project framework and the DPSIR categories.

TRANSPORTATION AND SERVICE CORRIDORS - D03 shipping lanes, ports, marine constructions (D03.01.02 piers / tourist harbours or recreational piers)

With regard to transportation, service corridors, marinas, and yachting activities, it should be noted that the Bay of Panzano is an extremely shallow stretch of water; there are therefore no relevant transport corridors except for the entrance to the port of Monfalcone, which is via a well-delimited entrance channel relatively far from the areas in which the pilot actions will be carried out.
Main data collected refer to:

- No. of marinas and main ports (pagineazzurre.com, https://webgate.ec.europa.eu/fleet-europa),
- No. of pleasure boats/marina (pagineazzurre.com),
- No. of fishing boats (Eu fleet register),
- No. of transits (derived from analysis of google earth images from years 2015-16-17 summer season).

There are twelve marinas that has a total 3500 leisure boats and there are only 42 fishing/acquaculture boats. Even if the zone analyzed appears strongly frequented, in the summer period on average about 500 boats stop in 5 main zones. The zones proposed for the positioning of the buoys (Activity 4.1) result among those with lower density value.

BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY - F01 Marine and Freshwater Aquaculture (F01.02 suspension culture), F02 Fishing and harvesting aquatic resource (F02.03 leisure fishing)

The data were collected with the support and collaboration of the fisheries and aquaculture associations that were interviewed individually. Also, the geographical data referring to fishing and aquaculture activities were collected through interviews but conducted with the use of cartography for the identification of artisanal fishing areas; the data were then digitized on GIS.
Main Data collected:

- No. of aquaculture facilities,
- Total surface area of the installations,
- Production of aquaculture farms,
- No. of fish farms,
- Surface of the installations,
- Average production (not yet recovered),
- No. of freediving fishermen,
- Average fishing days.

All data have been reported on GIS to better support further analysis.

There is only one large area dedicated to mussel and fish farming. Overall, there are about 400 rows of mussel farms and 63 floating tanks for fish farming. They cover an area of 370.000 m^2 and produce on average 1.200 tonnes/year of mussels.

It has not yet been possible to derive the average production of ichthyoculture. There are no fishing activities other than small-scale artisanal fishing conducted with small boats and mainly fishing with gillnets. The shallow-water area with seagrass meadows is a popular destination for free-diving fishermen. On the area there are about 30 freediving fishermen who operate for about 15 days/year. This is a type of fishery that has no significant effect on the seagrass meadows that merely takes advantage of the shelter effect. To them is added a professional fisherman authorized to operate with cylinders limited to certain species of molluscs.

HUMAN INTRUSIONS AND DISTURBANCES - G01 Outdoor sports and leisure activities, recreational activities (G01.07 scubadiving, snorkeling)

The human activities that cause disturbance in the area have been identified mainly among the sports activities such as diving and recreation or bathing with small boats. The area is famous for its kytesurfing activities, but this has no significant effect on seagrass meadows or habitats. Therefore, data have been collected on:

- No. of diving schools,
- No. of dives,
- Anchorage frequency,
- No. of boats,
- Boat size,
- Type of anchor.

The data collected showed that the diving activities, probably because of the shallow depth are very limited and although there are 3 diving schools in the area none of the three attend the project area except in an extremely sporadic way. Even if the zone analyzed appears strongly frequented, in the

summer period on average about 500 boats stop in 5 main zones. The zones proposed for the positioning of the buoys (Activity 4.1) result among those with lower density value. The boats are always below 10 m length also because of the limited seabed and the preferred anchorage method is “grappino” or umbrella.

POLLUTION - H03.02 toxic chemical discharge from material dumped at sea (H03.02.04 introduction of other substances - e.g., liquid, gas) and INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES (I01-invasive non-native species)

The causes of possible pollution are determined by the Valentinis Canal (derivation of the Isonzo river), Brancolo Canal, Isonzo river, Staranzano purification plant diffuser. The runoff of urban areas and the flooding of the river Isonzo can cause pollution. The quality and quantity of the inland waters flowing into the Bay of Panzano are linked to heavy rainfall. The increase in the flow of rivers (Isonzo and underground watercourses), the runoff of agricultural areas (Brancolo reclamation area), the venting of sewer overflows and the pipelines to the sea with their diffusers (Monfalcone port area, Staranzano purification plant) contribute to convey the pollutant to the sea.

High winds from the south and high tide can prevent the normal mixing of fresh water with sea water, allowing the pollutant charge to remain.

No “invasive non-native species” was found during monitoring activities and no recent observations are reported; however, this pressure has been considered because it could potentially occur at any time.

NATURAL SYSTEM MODIFICATIONS - J02.12 Dykes, embankments, artificial beaches, general (J02.12.01 Sea defense or coast protection works, tidal barrages)

All artificial works put in place to protect the coastline or modify and limit the effects of the waves have been evaluated. Coastal works were then considered and measured, distinguishing them into two categories: breakwaters and dikes. The area has about 1500 m of dams and 600 m of breakwaters.

4.3.2. Analysis of collected data for Kornati NP site

Quantitative and descriptive data have been provided directly by the park managers (http://www.np-kornati.hr/en) and reported in literature (Casier R., 2011; Mihelcic and Ramov, 2018; Ivković N., 2015).

Analyzing the table 3 the main pressures seem related to four drivers: "transportation and service corridors", "human intrusions and disturbances" "pollution" and "invasive species".

The drivers "natural biotic and abiotic processes" and "natural system modifications" could cause minor impact. Other possible pressures, not estimated now, can be related to the driver "biological resource use other than agriculture & forestry".

TRANSPORTATION AND SERVICE CORRIDORS - D03 shipping lanes, ports, marine constructions (D03.01.02 piers / tourist harbours or recreational piers)

Visitors to Kornati National Park (Kornati NP) can be divided into two basic groups, individual visitors and group visitors. The number of visits has increased over time, from 166.941 in 2015 to 172.603 in 2017 and it is about 195.230 in 2019 (according solely to the tickets sold). Especially in summer the Park can be busy because the majority of visitors is coming with private / rented vessels. There are four no-take zones where only scientific research is allowed. Sailing is allowed in the whole of the Kornati National Park except in the zones of strict protection. Anchoring and overnighting are permitted only at 19 locations (bays and coves).

Visitors can reach Park by their own boat (or rented one) or participating in organized daily tours provided by numerous individuals and/or tourist agencies that have contract with Public Institution Kornati NP.

Number of individual visitors is estimated number because tickets for individual boats are for the boats, not for the people on the board and price depends on length of the boat. Number of visitors on daily tours is also estimated number because organizer pays entrance ticket based on registered number of passengers on board.

There are receptionists in the Park, but they control tickets in small vessels, so it is very difficult to control the whole area. There are two official entrances but also numerous unofficial entrances.

The highest number of boats is registered in July and August. From November until March, there are just a few boats in the Park because weather conditions do not allow staying in the Park. All restaurants and the ACI marine Piskera are closed in that period.

There are seven categories of boats based on the length of boat:

1) up to 7 m
2) 7 m – 11 m
3) 11 m – 18 m
4) 18 m -25 m
5) 25 m – 50 m

6) 50 m -75 m
7) over 75 m

Data about number of individual boats by category, based on tickets purchased in 2017, 2018 and 2019 are reported in table 9.

Table 6. Number of individual boats by length in 2017, 2018 and 2019.

	Number of individual boats		
Category	**2017**	**2018**	**2019**
Up to 7 m	-	1.367	1.372
7 m – 11 m	4.892	3.163	2.764
11 m – 18 m	7.536	6.863	8.352
18 m – 25 m	321	320	345
25 m – 50 m	104	133	111
50 m – 75 m	8	15	13
over 75 m	9	10	10
TOTAL	**12.870**	**11.871**	**12.967**

Visitors on individual boats can buy ticket for 1, 3, 5 or 7 days. Daily ticket includes staying overnight in the Park, so boat usually moor at least one night in the Park. As a matter of anchoring pressure, these data should be condidered as minimum staying values.

Data about number of excursion boats, based on number of daily visits – organized groups, in 2017, 2018 and 2019 are reported in table 10.

Table 7. Number of excursion boats in 2017, 2018 and 2019.

	2017	**2018**	**2019**
Number of excursion boats	729	768	866

BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY - F02 Fishing and harvesting aquatic resource

Some illegal fishing has been reported especially during bad weather, when there is no surveillance. Spearfishing is forbidden in the Park, but divers have reported to see spear fishers at several occasions.

Professional fishing is forbidden in the Park, only artisanal fishing and recreational fishing are allowed, but they are also subject to regulations on the type of fishing gear and maximum catch.

There is a specific fishing regulation in Kornati National Park. From 2018, recreational fishing is regulated in this way:

- Only for landowners in Kornati NP who carry out traditional activities (sheep farming, olive tree growing). Landowners have exclusive rights for fishing in Kornati N.P. (recreational fishing – permit valid for one year - from January to December); in 2018, 42 fishing permits were sold and, in 2019, 44 fishing permits. There is no data for 2017 because recreational fishing permit system in protected areas didn't exist yet.
- Fishing only for food during their (landowners) stay in the area of the park.
- Longline (150 hooks), 3 fish traps, fishing lines. Traditional fishing for food with nets (150 m) is now forbidden.

HUMAN INTRUSIONS AND DISTURBANCES - G01 Outdoor sports and leisure activities, recreational activities (G01.01.01 motorized nautical sports, G01.07 scubadiving, snorkeling)

Autonomous diving is allowed only in organized groups, with a license for autonomous diving in the Kornati NP obtained in advance. Permits are not required for snorkelling and swimming, which may only be done within swimming zones – a distance of up to 50 metres from the shoreline (except in strict protection zones).

INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES - I01 invasive non-native species

The marine invasive species *Caulerpa cylindracea* (a green alga) and *Womersleyella setacea* (a red alga that grows over *Posidonia oceanica* rhizomes) have been observed in the last years and is spreading in the entire Park. Regressed seagrass meadows are prone to invasion by one or more of the potential substitutes for *P. oceanica* such as algal species (in particular, *C. cylindracea*).

POLLUTION – H01 Pollution to surface waters (limnic, terrestrial, marine & brackish) (H01.08 diffuse pollution to surface waters due to household sewage and waste waters) - H03 Marine water pollution (H03.01 oil spills in the sea - H03.03 marine macro-pollution - i.e., plastic bags, styrofoam)

The areas affected by industrial settlements are very few and very localized. Mostly, the most critical pollution phenomena are attributable to domestic wastewaters.

A World Bank 2018 (https://www.worldbank.org/en; www.eea.europa.eu) report highlights the need to eliminate coastal zone pollution to improve the quality of coastal waters, reducing eutrophication, and the risk of water-related diseases.

Wastewater services suffer from considerable backwardness, especially in coastal historic centers where adaptation and modernization works are difficult and expensive. Until 2010, only 44% of Croatians had adequate access to wastewater collection systems, resulting in a threat to environmental quality.

Important wastewater treatment and collection works, started by the Government, are clearly improving the conditions of the most critical coastal areas.

The situation along the coastal stretches where the dilution phenomenon is more enhanced is clearly better, so much so that the Report on the Croatian 2018 bathing waters indicates that 95% of the points monitored are of “excellent” quality.

Since the Dalmatian coast of Croatia is intensively used, there is plenty of litter that ends up in the sea. Marinas are a critical point of accumulation of marine litters. Since cleaning the seabed is a much more complicated practice than collecting along the shore, the most frequented bays by pleasure boats accumulate significant quantities of plastic, glass, and metal, such as bottles, drink cans, packaging, and more. This type of coastal areas, especially if far from the mainland coast, are hardly managed in cleaning. Small, relocated tourist settlements, such as restaurants and bars, also contribute to the dispersal of waste.

The situation of Kornati Park falls in an intermediate position: on the one hand the phenomenon of waste dispersion is remarkable; on the other, the increasing garbage collection practice (on the water and on land along the shore) is limiting the problem (https://www.worldbank.org/en; www.eea.europa.eu).

NATURAL BIOTIC AND ABIOTIC PROCESSES (WITHOUT CATASTROPHES) - K03 Interspecific faunal relations (K03.03 introduction of disease - microbial pathogens)

The cryptogenic parasite *Haplosporidium pinnae* is another possible threat, because it’s causing the collapse of *Pinna nobilis* populations and in 2019 mortality spots have been detected in South Croatia (Cabanellas-Reboredo M. *et al*., 2019; http://www.drustvo20000milja.hr/?p=1461&lang=en).

4.3.3. Analysis of collected data for RNP Coastal Dunes

The collection of quantitative data is based on two different methodologies:

1. data recovery from official reports of the main research institutes and monitoring bodies such as the regional environmental protection agency,
2. analysis of GIS data such as satellite images but also free access geodb as the The European Marine Observation and Data Network (*EMODnet*), etc.,

Data have been collected and harmonized according to the project framework and the DPSIR categories.

TRANSPORTATION AND SERVICE CORRIDORS - D03 shipping lanes, ports, marine constructions (D03.01.02 piers / tourist harbours or recreational piers)

With regard to transportation, service corridors, marinas, and yachting activities, it should be noted that in the "Litorale Brindisino" there are no relevant transport corridors.

Main data collected refer to:

- No. of marinas and main ports (pagineazzurre.com, https://webgate.ec.europa.eu/fleet-europa),
- No. of pleasure boats/marina (pagineazzurre.com),
- No. fishing boats (EU Fleet Register),
- No. of transits (preliminary data are derived from analysis of google earth images from years 2015-16-17 summer season).

There are six marinas that have a total 1143 leisure boats. Despite the significant number of berths in the marinas from the analysis of the two available dates of satellite photos (July 2017 and July 2018) the number of vessels is in both cases below 10 units showing a low frequentation of the area.

BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY - F01 Marine and Freshwater Aquaculture (F01.02suspension culture), F02 Fishing and harvesting aquatic resource (F02.01 Professional passive fishing, F02.02 Professional active fishing, F02.03Leisure fishing)

The data were collected essentially form the information gathered by Eurofleet agency and considering the reports provided by Local Action Coastal Group.

Main Data collected:

- No. of professional fishing boats,
- Type of Gears,
- Mean of working days/year.

The fishing fleet in the analysed area includes the marinas between Bari and Brindisi which are characterised as small-scale artisanal fisheries due to the small size of the vessels and the fishing gear used, counting on a limited number of demersal trawlers. The breakdown of GT (Gross Tonnage) classes by gear shows that the fleet uses essentially three types of gear, although in different percentages. The

area has a theoretical fleet of 334 vessels that declare 160 vessels equipped with set longlines as the main gear, then 105 with Bottom otter trawls and finally 58 with Set (anchored) gillnets; 10 purse seines and only one for drift gillnets. There are evidently the most numerous boats equipped with longlines, but there are potentially many boats equipped for trawling whose signs seem to be found even below the coast, even where this type of fishing should be prohibited. Anyway, this versatility in fishing systems ensures variety in the fish species caught. An interesting fact is concerning the average working days, which seem to differ greatly between marinas, varying from marinas with an average of 120 working days year to others with more than 170 days per year.

Given these data, the proposed eco-friendly buoy area lays on low pressure fishing sea stretch, as reported in BIOMAP (Apulia Region platform fro bioconstruction valorization - http://www.sit.puglia.it/portal/portale_rete_ecologica/biomap).

HUMAN INTRUSIONS AND DISTURBANCES - G01 Outdoor sports and leisure activities, recreational activities (G01.01.01 motorized nautical sports, G01.01.01 non-motorized nautical sports, G01.07 scubadiving, snorkeling) - G05 Other human intrusions and disturbances (G05.02 shallow surface abrasion / mechanical damage to seabed surface, G05.03penetration / disturbance below surface of the seabed)

The human activities that cause disturbance in the area have been identified mainly among the nautical sports activities such as sky, diving and recreation or bathing with small boats. The area is not very known for diving but is well used by snorkeler with several companies involved in offering snorkeling activities. Therefore, data have been collected on:

- No. of diving schools,
- No. of snorkeling service companies,
- Anchorage frequency,
- No. of boats,
- Type of anchor.

The data collected showed that the diving activities, probably because of the shallow depths are very limited and although there are 5 diving schools in the area, none of them attend the project area except in first activities.

The preliminary analysis of the only available useful images (08/07/2017 and 19/07/2018) show a very low number of boats present in the area. The preferred anchorage method is “grappino” or umbrella.

POLLUTION - H03 Marine water pollution (H03.01 oil spills in the sea, H03.02.01 non-synthetic compound contamination, H03.02.02 synthetic compound contamination, H03.03 marine macro-pollution - i.e. plastic bags, styrofoam) and INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES - I01-invasive non-native species

Several human activities contribute to the emission of nutrients and compounds to the marine environment, such as treatment plant (with their wastewater). Nutrients and compounds are brought to

the sea by direct waterborne discharges in marine and coastal waters (direct inputs) or with river inflow (riverine inputs).

Currently in the proximity of the study area, there are two wastewater treatment plants: 1) the Ostuni plant where wastewater and olive mill wastewater are treataed and partially reused in agriculture 2) the Fasano-Forcatella plant, where wastewaters already treated in the municipal plant and otherwise destined for discharge to the sea in Table 1 (Legislative Decree 152 / 2006), are further treated and reused in agriculture; in this way, in normal operating conditions, the is not discharge to the sea.

Regarding, the main sources of oil spills in the marine and coastal environment are direct discharges from shipping. However, river water flowing into the sea may also be contaminated with oil.

No “invasive non-native species” was found during monitoring activities even if *Caulerpa cylindracea* (a green alga) and *Womersleyella setacea* (a red alga that grows over *Posidonia oceanica* rhizomes) have been observed in the last years along the apulian coasts (http://www.sit.puglia.it/portal/portale_rete_ecologica/biomap/Documenti). For this reason, this pressure has been considered because it could potentially occur at any time.

NATURAL BIOTIC AND ABIOTIC PROCESSES (WITHOUT CATASTROPHES) - K01 abiotic (slow) natural processes (K01.01 Erosion, K01.02 Silting up), K02 Biocenotic evolution, succession (K02.01 species composition change (succession), K02.02 accumulation of organic material, K02.03 eutrophication - natural) - K04 Interspecific floral relations (K04.01 competition, K04.02 parasitism, K04.03 introduction of disease (microbial pathogens), K04.05 damage by herbivores (including game species)

On the basis of the available data (Autorità di Bacino della Puglia e Politecnico di Bari, 2010), there emerges a generalized phenomenon of frontal erosion affecting the shoreline and - consequently - a retreat of the dune wreck that runs for large stretches of the coast in question. As for the seabed, the alternating presence of large *P. oceanica* coverings, sections of dead matte and sandy bare bottom does not seem justified by direct phenomena of anthropogenic origin disturbance, but rather by a natural evolution of the coverage pattern, indirectly by increased turbidity due to the exposure to the winds of the first and second quadrants and from competition by *Caulerpa prolifera*, an indigenous species, which with its strong colonizing trend is producing a considerable shift of the vegetation pattern in the areas in question.

As for parasitism phenomena, it should be noted the diffusion of the parasite *Haplosporidium pinnae*; as mentioned before, this species is decimating the populations of the bivalve *Pinna nobilis* throughout the Mediterranean Sea (https://www.iucn.org/news/mediterranean/202001/ mediterranean-noble-pen-shell-crisis-pinna-nobilis-january-2020-update).

4.4. A States description through preliminary survey data (WP 3 Activity 1)

The main results of the preliminary surveys (WP 3 activity 1) carried out in the three project sites are reported in subparagraphs. The data collected help to describe the "state" of the environment, the quality of the various environmental compartments affected by pressures.

In the three study sites, during the surveys, the potentially impacted states that have been considered are: seagrass meadows and surface sediments, benthic communities, bivalve *Pinna nobilis* and water column.

Some indicators were considered as more relevant in describing the ecosystem quality, especially considering how the data collected and examined in this report will be the basis and therefore a fundamental part in the construction of the GIS platform (WP 5, Activity 1), and in defining the measures of conservation and mitigation in the use of the habitats of interest (WP 5, Activity 2).

In particular, regarding the state "water column", as mentioned before, it is important to underline that the single value or the average of some values of some parameters (such as water temperature, transparency, etc.) cannot be directly connected to the pressure acting on the site if not through an expert evaluation. For this reason, biological indices have been considered to describe this "state".

In the table 6 the "state indicators" considered in the analysis are summarized for each potentially impacted state.

Table 8. "State indicators" considered in the analysis summarized for each potentially impacted state.

Potentially impacted state	**State Indicators ***
Seagrass meadows	- percentage cover - shoot density and length - leaf lenght and width - leaf necrosis - No. of leaves
Surface sediments	- Pelite / Sand - Total Phosphorus, Nitrogen and Carbon
Benthic communities	- macroalgal species (phyla percentage) - epiphyte morpho-functional categories (coverage percentage) - macrozoobenthic communities (main groups percentage)
Bivalve *Pinna nobilis*	- No. of alive individual
Water column	- Indices (e.g., Trophis status index)

* = indices for water column

4.4.1. Data collected in field during for Monfalcone site (Bay of Panzano)

The preliminary surveys, in the Bay of Panzano, have been carried out in three zones (Figure 9).

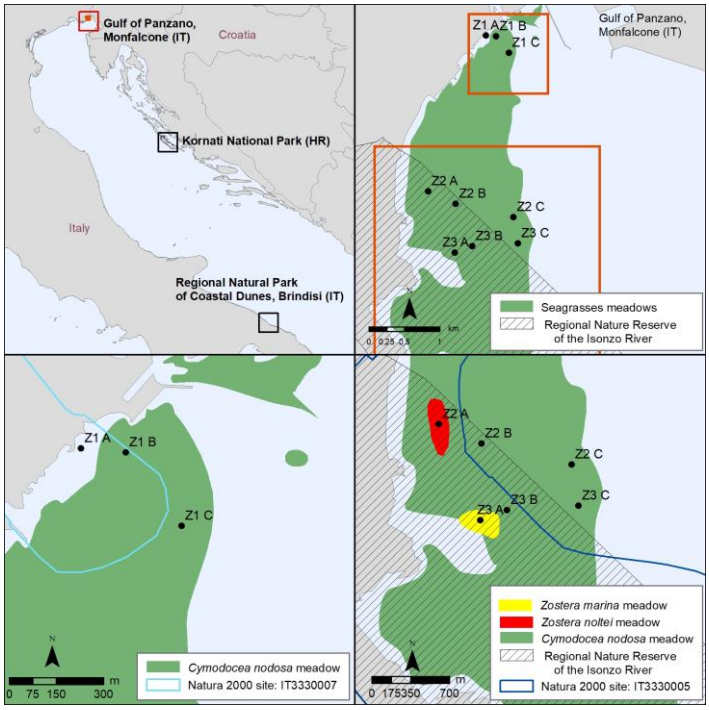

Figure 9. Seagrasses distribution and monitoring stations in the Bay of Panzano.

Three monitoring stations were positioned (A, B and C), within each Zone, at different depths, for a total of nine stations. The Zone 1 (Z1) was located in the northern part of the Bay of Panzano, inside the site SAC "Cavana di Monfalcone", on a *Cymodocea nodosa* meadow. The Zone 2 (Z2) and Zone 3 (Z3) were placed in the SPA-SAC "Foce dell'Isonzo – Isola della Cona". These Zones were characterized by shallow depth and were positioned on *C. nodosa* meadows mixed with other species (i.e., *Zostera noltei* in Z2 and *Zostera marina* in Z3).

Seagrass meadows and surface sediments

This area is completely different from these of Kornati NP and RNP Coastal Dunes because it is located in a shallow bottom in the Bay of Panzano near the outflow of the river Isonzo. The trophic conditions and water turbidity are higher than in the other areas and they do not allow the presence of *P. oceanica*. Instead, there are other species of lower ecological value but equally important because they are adapted to higher trophic conditions. Among these, the dominant species is *Cymodocea nodosa* that forms extensive prairies throughout the bay (Figure 9).

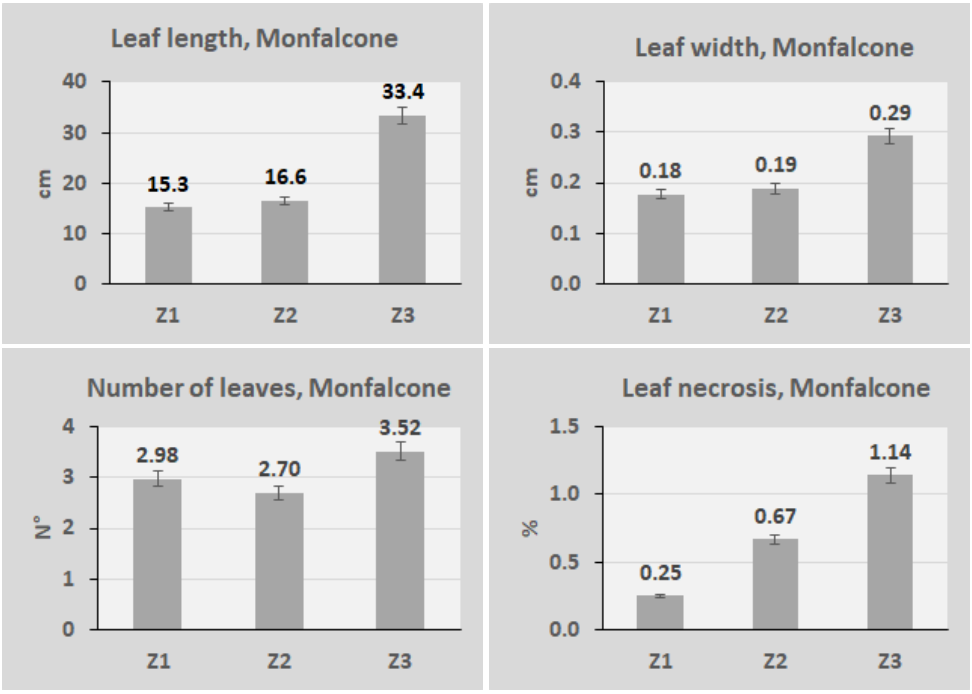

Figure 10. Metrics of Cymodocea nodosa at Monfalcone.

Cymodocea nodosa is a seagrass much smaller than *P. oceanica*. In addition, sampling was carried out in the spring when this species is starting to grow after spending the winter without leaves. Therefore, the **height of leaves** is only 15-16 cm (Figure 10) in the shallower zones where the winter temperature of surficial water is lower and and approx. twofold higher in the deepest zone (Z3) where the winter temperature is higher. The same situation is observed for the **leaf width**, the **number of the leaves** per shoot and the leaf necrosis that increased with depth and in the summer season. However, it should be noted that the necrosis in *C. nodosa* was much lower than that in *P. oceanica* because, at the beginning of the season, the plants of *C. nodosa* are in full growth.

For **percentage cover** and **shoots density**, the data analysis suggests the existence of limited differences along stations and zones, related to the presence of species (*C. nodosa* e *Zostera* spp.) characterized by different seasonal cycles (growth rate and spread, reproductive season, etc.) (Table 7). For **shoots length**, compared to *C. nodosa* average shoot length, the lower one of *Z. noltei* and the greater one of *Z. marina* are expected and due to different phenological cycles (Table 7).

Table 9. Percentage cover, shoots density and shoot length average values for the three sampling zones.

	Percentage cover	Shoots density (m^2)	Shoots length (cm)
Z1	92-100 (C.n.) [1]	437-548 (C.n.) [1]	12,2-18,3 (C.n.) [1]
Z2	97-100 (C.n.) [1] / 77 (Z.n.) [1]	719-798 (C.n.) [1] / 2111 (Z.n.) [1]	16,2-24,2 (C.n.) [1] / 9,3 (Z.n.) [1]
Z3	100-100 (C.n.) [1] / 100 (Z.m.) [1]	652-776 (C.n.) [1] / 319 (Z.m.) [1]	24,0-29,2 (C.n.) [1] / 46,9 (Z.m.) [1]

[1] Average value range of two stations. [2] Average value of one station.

Samples of the 5 cm sediment top layer and seagrasses were collected. At Monfalcone (Bay of Panzano) the amount of Fines (Pelite) (Figure 11) is similar to that recorded at Kornati NP. In the zones Z1 and Z2 the percentage of pelite was approx. 23%, but it increased to 32.6% in Z3. The concentration of Ptot increased significantly from Z1 to Z3 whereas the other nutrients were not related to the depth.

At Monfalcone leaf length and leaf width showed positive significant correlations with the concentration of Organic Phosphorus (Porg) (Figure 12). In addition, leaf necrosis was obviously correlated with the increasing leaf length and leaf width.

The PCA analysis shows that in this station all the *C. nodosa* metrics are grouped in the right side of the biplot in opposition to the sediment parameters, indicating that the plants are negatively affected by the high eutrophication present in this area.

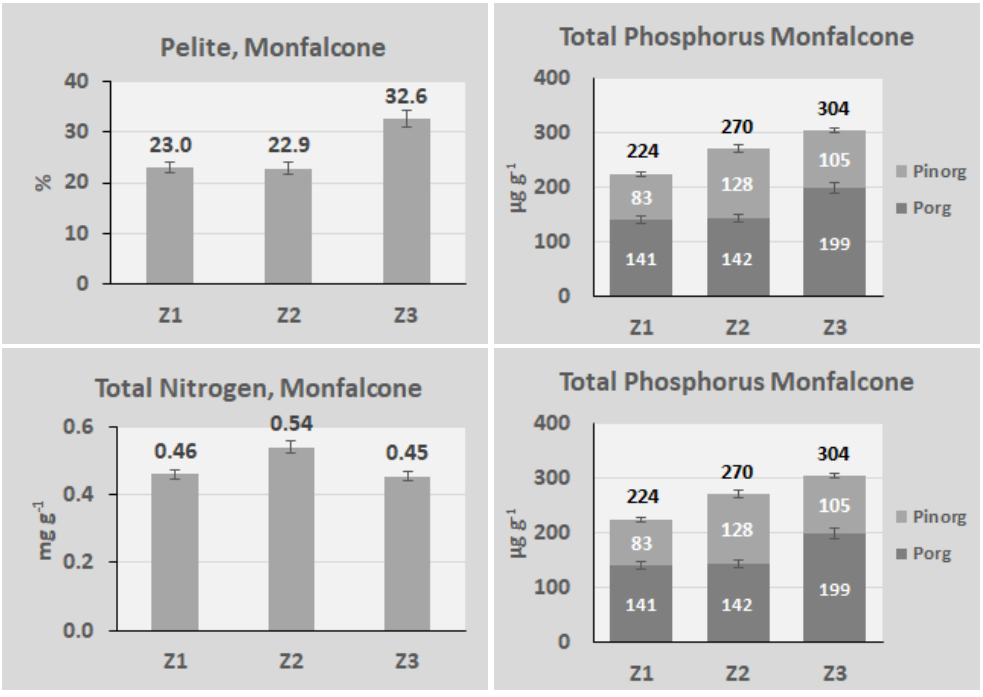

Figure 11. Concentrations of fines (Pelite), Total Carbon, Total Nitrogen, Total Phosphorus at Monfalcone.

Significant non-parametric correlations at Monfalcone						
	Cymodocea nodosa		Surface sediments			
	Shoot length	Shoot width	Ctot	Ntot	Ptot	Porg
Shoot width	0.93					
Leaf necrosis	0.82	0.92				
Ntot			-0.74			
Porg	0.78	0.75	0.69		0.73	
Pinorg					0.68	
Sand					-0.79	-0.79
Pelite			0.95	-0.80		
In Black p<0.05 per r ≥ |0.67|. In Red 0.01 per r ≥ |0.81|						

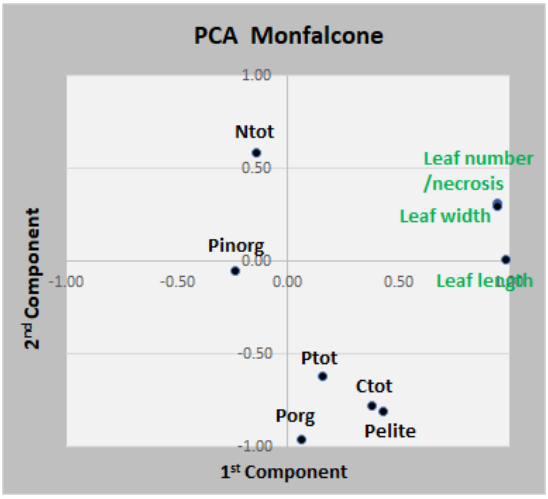

Figure 12. Non-parametric coefficients and PCA between C. nodosa metrics and sediment parameters.

Benthic communities

The principal macroalgal species found were related to Chlorophyta (37%), Ochrophyta (21%) and Rhodophyta (42%). Considering the epiphytes, they have been classified into three morpho-functional categories and the average cover has been calculated: *encrusting* (encrusting or prostrate algae, 15%), *turf* (algae less than 10 mm long, <5%) and *erect* (algae greater than 10 mm, <5%). The dominance of the *encrusting layer* (represented above all by the Corallinales) is reported in literature as a positive condition of the quality status of seagrass meadows. In fact, in disturbed environments (e.g., in the presence of nutrient increase or turbidity), there would be a reduction in encrusting layers abundance and a simultaneous increase in filamentous algae presence (Ballesteros, 1987; Martínez-Crego *et al.*, 2010). In the study area, during the monitoring activities, no alien algal species were found.

A rapid assessment of the associated macrozoobenthic communities detected the presence of the species related to Anthozoa (4%), Crustacea Amphipoda (4%), Crustacea Decapoda (13%), Crustacea Isopoda (9%), Mollusca Bivalvia (26%), Mollusca Gastropoda (30%) and Polychaeta (3%).

The bivalve *Pinna nobilis*

Pinna nobilis was found only in Zone 1 station for a total of 4 alive bivalves (3 adult individuals and 1 young individual). These data are consistent with what reported for the Northern Adriatic (Gulf of Trieste), where 60-70% of individuals are already dead (from Muggia to Sistiana) and the cause of the death is the parasite *Haplosporidium pinnae* which is decimating the populations of the bivalve throughout the Mediterranean Sea (http://www.greenreport.it/news/aree-protette-e-biodiversita/strage-di-pinne-nobilis-anche-nel-golfo-di-trieste-da-muggia-a-sistiana-il-60-70-degli-individui-e-gia-morto/ - 24 Janaury 2020)

Water column

Regarding the water column state, reference was made to the data published by the Regional Agency for the Protection of the Environment of Friuli Venezia Giulia (ARPA FVG) (http://www.arpa.fvg.it/cms/tema/acqua/). According to ARPA FVG Reports on the Water Framework Directive monitoring results the analyses of the physico-chemical elements, summarised in the TRIX index (trophic status index), and the supporting chemical elements in the water (DM 260/10) show "good ecological status". Bathing is basically always guaranteed except in rare cases. For the 2017, 2018 and 2019 seasons, the calculation model applied for the determination of quality (Legislative Decree 116/08) has allowed the area to be classified as "excellent".

In the table 8, the possible pressures and their potential effects on the states, highlighted during the survey activities, are summarized.

Table 10. Possible pressures and their potential effects on the states, highlighted during the survey activities.

Pressure	Potential effects on states
G05.03 penetration/ disturbance below surface of the seabed	**Seagrass meadows**: the presence of small and medium boats (sailboats) seems not to affect the meadows that are characterized by a high continuity and no particular signs of disturbance.
K03.03 introduction of disease (microbial pathogens)	***Pinna nobilis***: 4 alive bivalves (3 adult individuals and 1 young individual) were found. (Data consistent with what reported for the Northern Adriatic (Gulf of Trieste), where 60-70% of individuals are already dead because of the parasite *Haplosporidium pinnae*).

4.4.2. Data collected in field for Kornati NP

In the Kornati NP site, two typologies of sites, positioned on *P. oceanica* meadows, have been considered: the first one is the "Anchoring site" in Kravljačica Bay and the second one is the "Diving site", located between Borovnik island and Balun Island (Figure 13).

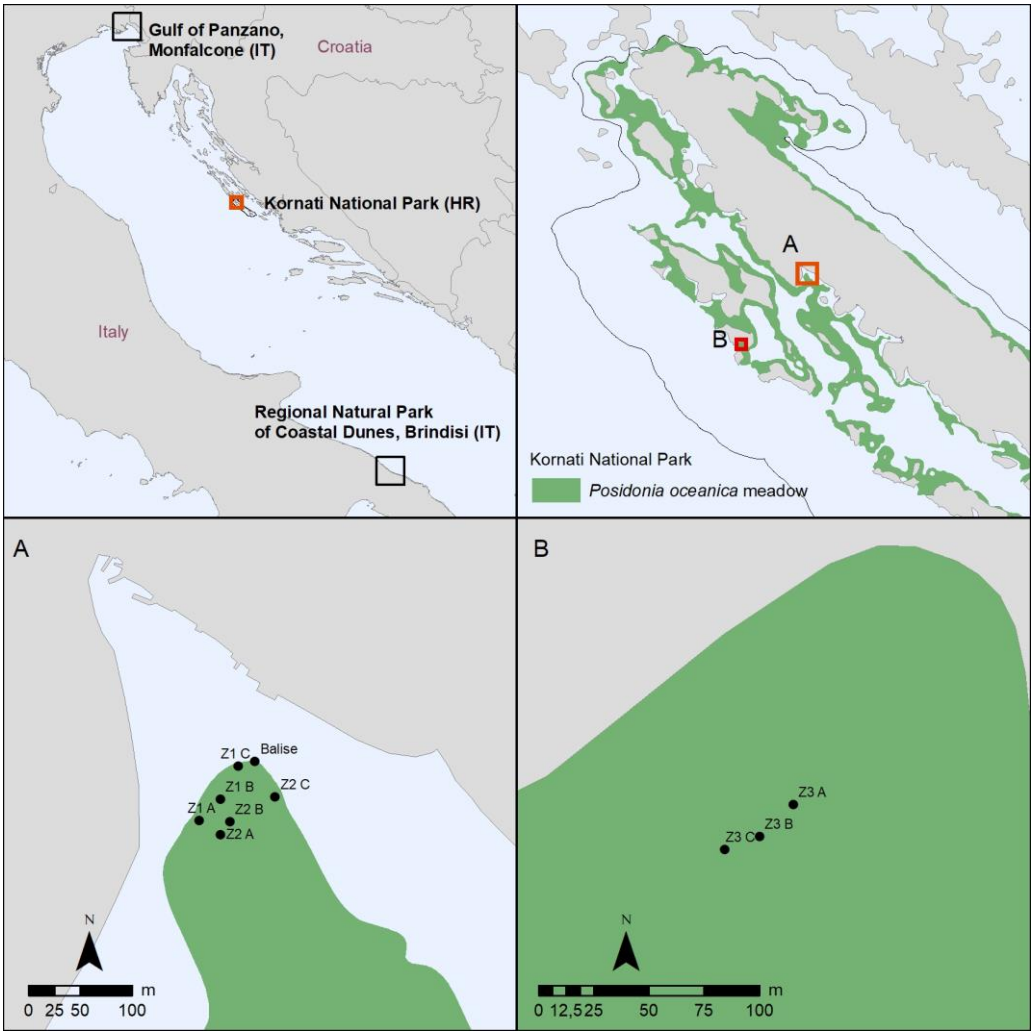

Figure 13. Seagrasses distribution and monitoring stations in the Kornati NP.

In the first one, two monitoring Zones have been selected (Zone 1 and Zone 2) and in the second one only one monitoring Zone (Zone 3) has been selected. Three monitoring stations were positioned (A, B and C), within each Zone, at different depths, for a total of nine stations (Figure 13).

Seagrass meadows and surface sediments

Samples of the 5 cm sediment top layer and seagrasses were collected during the field surveys. On an overall view, P. *oceanica* meadows are widespread in the park, down to depths of 25-30 meters and with an irregular distribution that mainly follows the bathymetric pattern of the archipelago. Existing rough distribution map considering historical data (document not official) was produced based on available orthophoto and bathymetric maps. This map represents potential distribution range. There is a need for more detailed seagrass distribution maps based on real data collected in the field. In the "Anchoring site" (Zone 1 and Zone 2) signs of disturbance on the meadows were reported and, in some areas, coverage is discontinuous and patchy and the damage to seagrasses seems caused by anchor dragging and scraping anchor chains along the seabed. The "Anchoring site", due to its morphology, bathymetric trend, and exposure to the wind, behaves like a sedimentation basin. **At present, it is reasonable to assume that even the numerous anchorages of pleasure boats, in the summer period, are responsible for an important phenomenon of sediment re-suspension**.

In the "Diving site" (Zone 3) the meadow was continuous with **no visible signs of disturbance and low sedimentation**; only some points were devoid of meadows, but this is believed to be due mainly to natural distribution dynamics and not to human activities impact.

For the **percentage cover** and **shoot density** of *P. oceanica*, the data analysis suggests the existence of differences in the along stations in the "Anchoring site" and in the "Diving site". In particular, the stations placed in the "Diving site" were characterized by these two parameters values higher than the ones of the "Anchoring site" (Table 11). This is an expected result because, as mentioned before, in the "Anchoring site" *P. oceanica* meadows suffer from mechanical damage caused by boats anchoring, caused by dragging anchors and scraping anchor chains along the seabed. Unlike the previous parameters, as concern the **shoot length**, the existence of differences along stations in the "Anchoring site" and in the "Diving site" were less evident (Table 11); however, even in this case, they seemed related, at least in part, to the presence or the reduced presence of anchoring pressure.

Table 11. Percentage cover, shoots density and shoot length average values for the three sampling zones.

	Percentage cover	Shoots density (m^2)	Shoots length (cm)
Z1	27-34	83-154	37,9-46,7
Z2	28-78	119-149	48,2-52,4
Z3	75-85	203-368	49,4-61,7

The **leaf length** and width of *Posidonia oceanica* showed an inverse trend. Leaf length increased from Z1 to Z3 whereas the opposite was recorded for **leaf width** (Figure 14). Conversely, the **number of leaves** per shoot did not show significant differences but leaf necrosis increased from 18,6% in Z1 to 57,4 in Z3% showing a considerable plant disconfort.

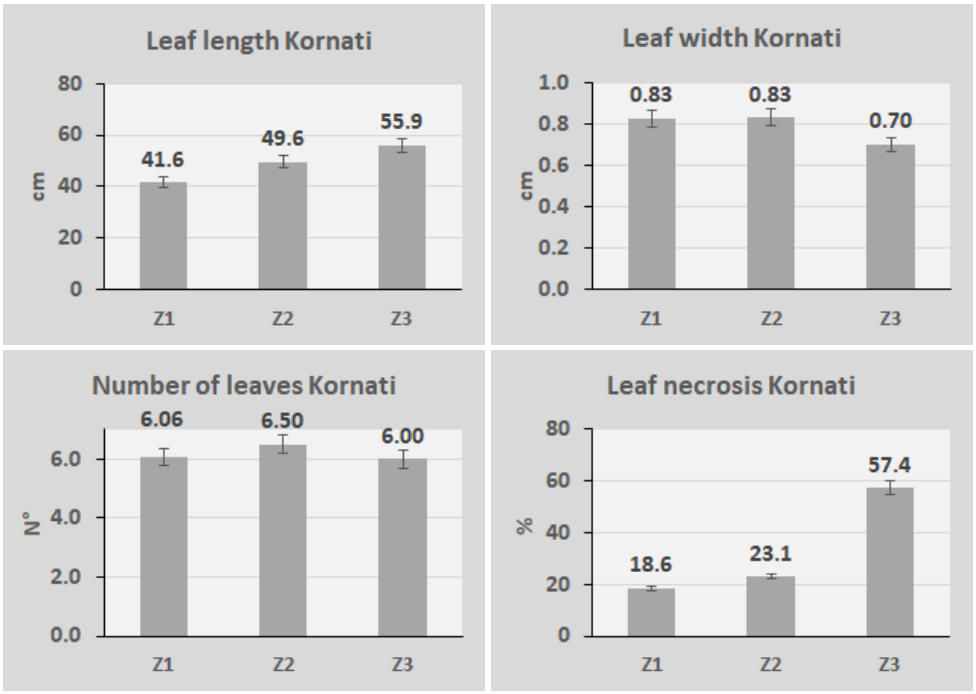

Figure 14. Metrics of Posidonia oceanica at Kornati.

The surface sediments of this area showed a relatively high amount of fine sediments (Figure 15). Indeed, Pelite (Fines = fraction <63 µm) ranged between 22,9% and 31,4% with the highest values in the stations of Z2. In the same zone the highest values of Total Carbon (Ctot) and Total Nitrogen (Ntot) were also recorded, whereas Total Phosphorus (Ptot) decreased from Z1 to Z3.

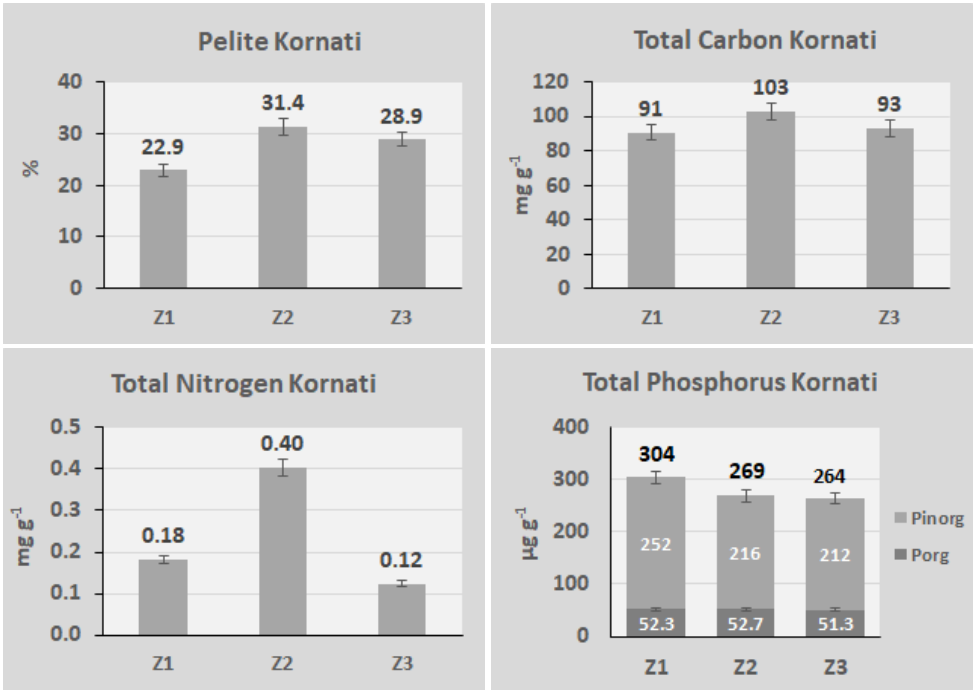

Figure 15. Concentrations of Fines (Pelite), Total Carbon, Total Nitrogen and Total Phosphorus in the three zones at Kornati.

The Spearman non-parametric coefficients between sediment parameters and *P. oceanica* metrics showed significant inverse correlations between nutrient concentrations and the leaf length but not with the the other metrics (Figure 16).

Significant non-parametric correlations at Kornati

	Posidonia oceanica	Surface sediments		
	Shoot length	Ctot	Ptot	Pinorg
Ntot	-0.68			
Ptot	-0.75			
Pinorg	-0.67	0.98		
Sand		-0.79	0.69	0.74
Pelite		0.79	-0.69	-0.74

In Black p<0.05 per r ≥ |0.67|

In Red 0.01 per r ≥ |0.81|

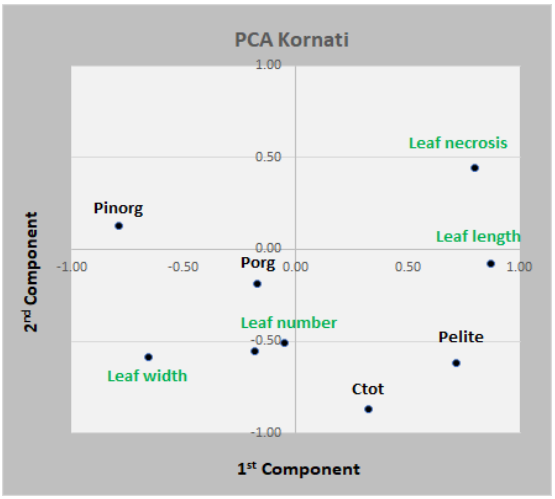

Figure 16. Non -parametric coefficients and PCA between P. oceanica and sediment parameters.

The PCA analysis explained a variance of 63,6% with the first two components increasing until 79% with three components. Leaf necrosis was associated to leaf length and the concentrations of pelite. Leaf width and leaf number with nutrient concentrations (Figure 16).

Benthic communities

The principal macroalgal species found are related to Chlorophyta (42%), Ochrophyta (25%) and Rhodophyta (33%). The epiphytes have been classified into three morpho-functional categories and the average cover has been calculated: *encrusting* (encrusting or prostrate algae, 30%), *turf* (algae less than 10 mm long, 6%) and *erect* (algae greater than 10 mm, 11%). As for the Monfalcone sites, the dominance of the *encrusting layer* (represented above all by the Corallinales) can be considered a positive condition of the quality status of seagrass meadows. Even if the marine invasive algal species *Caulerpa cylindracea* and *Womersleyella setacea* have been observed in the last years, spreading in the entire Park, during the monitoring activities in the "Anchoring site" and in the "Diving site", no alien algal species were detected.

A rapid assessment of the associated macrozoobenthic communities detected the presence of the species related to Anthozoa (4%), Crustacea Decapoda (4%), Crustacea Tanaidacea (4%), Echinodermata (4%), Mollusca Bivalvia (19%), Mollusca Gastropoda (22%) and Polycaheta (44%).

The bivalve *Pinna nobilis*

Some alive individuals of Pinna nobilis were found only in the proximity of Zone 3 (outside the monitoring corridor). In the Zone 3 and Zone 1, no individuals were found and, in the Zone 2 (st. Z2-B), the presence of one dead bivalve was reported.

Water column

The areas affected by industrial settlements are very few and very localized. Mostly, the most critical pollution phenomena are attributable to domestic wastewaters. A World Bank 2018 (https://www.worldbank.org/en; www.eea.europa.eu) report highlights the need to eliminate coastal zone pollution to improve the quality of coastal waters, reducing eutrophication, and the risk of water-related diseases. The situation along the coastal stretches where the dilution phenomenon is more enhanced is clearly better, so much so that the Report on the Croatian 2018 bathing waters indicates that 95% of the points monitored are of "excellent" quality. (https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/assessments/state-of-bathing-water/country-reports-2018-bathing-season/bwd 2018-nationalreport-hr.pdf/view). In the Report on the the Water Framework Directive River Basin Management Plans for **Croatia** (second RBMP), monitoring results show "Moderate (about 30% of water bodies) and Good (about 70% of water bodies) Ecological Status".

In the table 12, the possible pressures and their potential effects on the states highlighted during the survey activities are summarized and reported for the Anchoring site and the diving site.

Table 12. Possible pressures and their potential effects on the states, highlighted during the survey activities, for the Anchoring site and the diving site.

Anchoring site	
Pressure	**Potential effects on states**
G05.03 penetration/ disturbance below surface of the seabed	**Seagrass meadows**: the presence of small and medium boats (sailboats) seems to affect the meadows that are characterized by a discontinuous and patchy coverage. Presence of signs of disturbance related to anchor dragging and scraping anchor chains along the seabed.
K01.02 Silting up	**Seagrass meadows**: the site is a very protected and near-enclosed bay and behaves like a sedimentation basin (increase of siltation of seagrass leaves) thanks to a smooth bathymetric trend and exposure to the wind.
K03.03 introduction of disease (microbial pathogens)	***Pinna nobilis***: only one dead bivalve found. The possible presence of the parasite *Haplosporidium pinnae* is a potential threat, because it is causing the collapse of *Pinna nobilis* populations and in 2019 mortality spots have been detected in South Croatia.

Diving site	
Pressure	**Potential effects on states**
G01.07 scubadiving, snorkelling	**Seagrass meadows**: the presence of authorized scubadivers seems not to affect the meadows that are characterized by a high continuity and no particular signs of disturbance. Only some points were devoid of meadow.
G05.03 penetration/ disturbance below surface of the seabed	**Seagrass meadows**: the presence of diving boats anchoring for authorized diving activities seems not to affect the meadows that are characterized by a high continuity, no sedimentation, and no particular signs of disturbance. Only some points were devoid of meadow.
K03.03 introduction of disease (microbial pathogens)	***Pinna nobilis***: no alive bivalves were found in the monitoring area, but some alive individuals were observed outside of it. As for the Anchoring site, the possible presence of the parasite *Haplosporidium pinnae* is a potential threat.

4.4.3. Data collected in field for Regional Natural Park of Coastal Dunes

In the Regional Natural Park of Coastal Dunes site, the study area is placed about 500 meters from the coast and the monitoring zones are arranged almost parallel to the coastline. Z1 is the nearest Zone, Z3 the farthest one. The three Zone were located on a *P. oceanica* meadow, where anchoring pressures occur, due to the presence of medium boats. Within each Zone, three monitoring stations have been positioned at different depths.

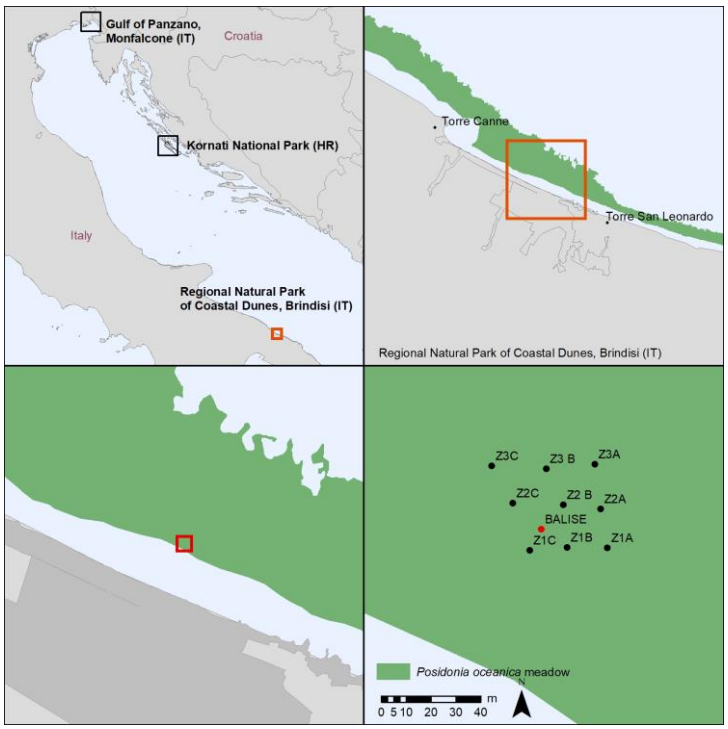

Figure 17. Seagrass distribution and monitoring stations in the RNP Coastal Dunes.

Seagrass meadows and surface sediments

Samples of the 5 cm sediment top layer and seagrasses were collected during the field surveys. The presence of *P. oceanica*, along the coast of the park, has been detected at a few hundred meters offshore, at a depth of about 7 meters, where the upper limit showed an irregular course.

In the site identified for the measurements and to carry out the pilot transplantations, the meadow coverage was about 70-75%, on matte with the presence of numerous inter-matte areas of sandy deposition.

Several surfaces of mattes have been observed where marine seagrass has certainly retreated, for reasons not directly connectable to anthropogenic pressure, presently.

For **percentage cover**, the data analysis suggests the existence of differences along stations between Zones 1 and 2 and Zone 3, because the stations placed in the Zone 1 and Zone 2 are characterized by values that are higher than the ones of the Zone 3. Unlike what was found for percentage cover, for **shoots density**, the data analysis suggests the existence of limited differences along stations and Zones. For **shoot length**, there are limited differences along stations and Zones (especially in Zone 3).

Table 13. Percentage cover, shoots density and shoot length average values for the three sampling zones.

	Percentage cover	Shoots density (m^2)	Shoots length (cm)
Z1	76-88	278-345	33,9-57,8
Z2	59-80	271-214	38,9-63,0
Z3	21-26	331-380	59,6-64,1

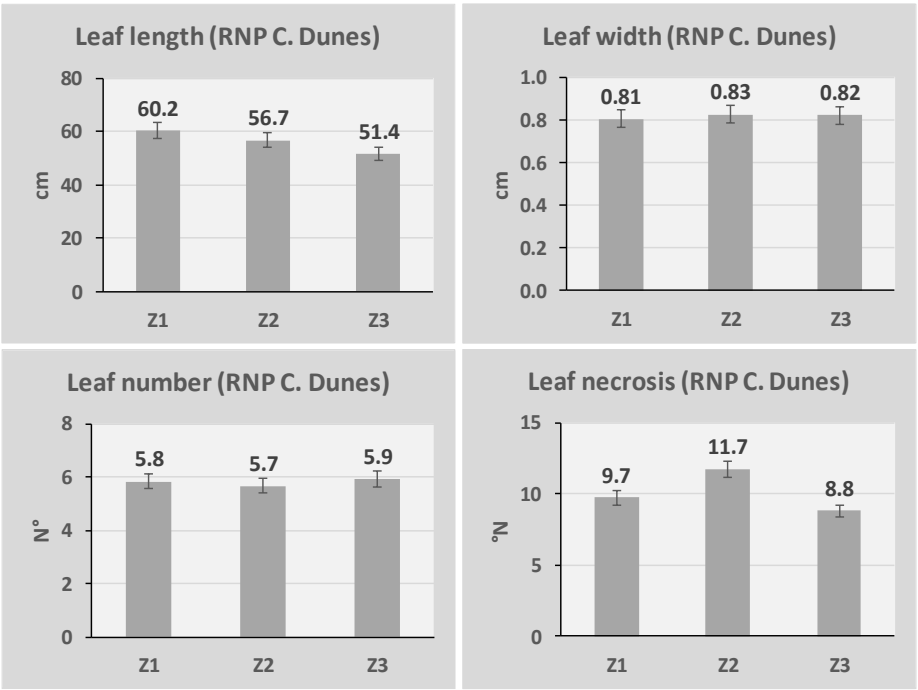

Figure 18. Metrics of Posidonia oceanica at RNP Coastal Dunes.

Leaf length of *P. oceanica* decreased with the depth whereas **leaf width** and **leaf number** were quite similar (Figure 18). The **leaf necrosis** was the highest in the intermediate depth probably due to some local impact.

The surface sediments of this area were almost completely sandy. The concentration of Fines (Pelite) in surface sediments was very low ranging from 3,2% to 3,7% and increased sligthly from Z1 to Z3 with the

increasing depth (Figure 19). Total Nitrogen and total Phosphorus, that are generally linked to the fine fraction, showed the same pattern with the highest values in the deeper zone. In contrast, Ctot was lower in Z2 without a trend related to depth.

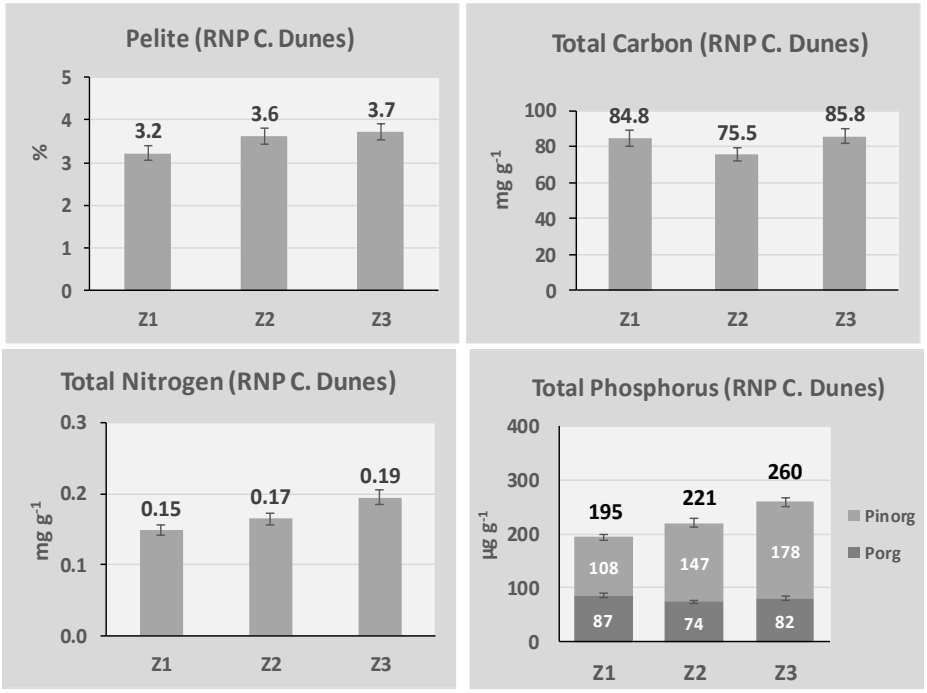

Figure 19. Concentrations of Fines (Pelite), Total Carbon, Total Nitrogen and Total Phosphorus at at RNP Coastal Dunes.

In this area, the number of correlations between the *P. oceanica* metrics and the sediment parameters was very scarce probably due to the exposure to the open and depth sea that does not allow a direct relationship between the nutrients trapped in surface sediments (Figure 20).

Significant non-parametric correlations at Dune

	Posidonia oceanica	Surface sediments	
	Shoot length	Ptot	Pinorg
Shoot width	-0.71		
Pinorg		0.98	
Pelite		0.90	0.82

In Black p<0.05 per r ≥ |0.67|
In Red 0.01 per r ≥ |0.81|

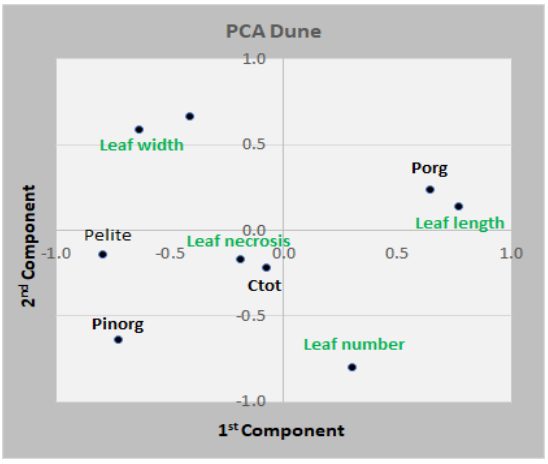

Figure 20. Non-parametric coefficients and PCA between P. oceanica metrics and sediment parameters.

The PCA showed a strong association between leaf length and Porg, leaf width and Ntot. Leaf necrosis was associated to Ctot and was placed in the same side of Pelite and Pinorg (Figure 20).

Benthic communities

The principal macroalgal species found are related to Chlorophyta (50%), Ochrophyta (12%) and Rhodophyta (38%). The average cover of the epiphytes three morpho-functional categories has been calculated: *encrusting* (encrusting or prostrate algae, 34%), *turf* (algae less than 10 mm long, 7%) and *erect* (algae greater than 10 mm, 5%). As for the other sites, the dominance of the *encrusting layer* (represented above all by the Corallinales) can be considered a positive condition of the quality status of seagrass meadows. In the study area, during the monitoring activities, no alien algal species were found. However, it is important to emphasize the abundant presence of *Caulerpa prolifera* (a "green alga"), an indigenous species related to the dangerous *Caulerpa taxifolia* and *Caulerpa cylindracea* which are invading some areas of the Mediterranean. In fact, regressed meadows are prone to invasion by one or more of the potential substitutes for *P. oceanica* such as this algal species (in particular, *C. racemosa*) or the other common Mediterranean seagrass *Cymodocea nodosa*.

A rapid assessment of the associated macrozoobenthic communities detected the presence of the species related to Anthozoa (3%), Cephalocordata (3%), Crustacea Decapoda (11%), Echinodermata (6%), Mollusca Bivalvia (28%), Mollusca Gasteropoda (28%), Mollusca Polyplacophora (3%), Polychaeta (17%) and Sipunculida (3%).

The bivalve *Pinna nobilis*

In the study area (within the corridors and in their proximity), no alive or dead individuals of *Pinna nobilis* were found.

Water column

Regarding the water column state, reference was made to the data published by the Regional Agency for the Protection of the Environment of Puglia (ARPA Puglia) (http://www.arpa.puglia.it). According to ARPA Puglia Reports on the Water Framework Directive monitoring results the analyses of the physico-chemical elements, summarised in the TRIX index (trophic status index), and the supporting chemical elements in the water (DM 260/10 and e D.Lgs. 172/2015) show "good ecological status" for the project site. Bathing is basically always guaranteed except in rare cases according to the calculation model applied for the determination of quality (Legislative Decree 116/08). The evaluation for the 2015-2018 period show an "excellent" quality (https://www.sanita.puglia.it/acque-di-balneazione).

In the table 14, the possible pressures and their potential effects on the states highlighted during the survey activities are summarized.

Table 14. Possible pressures and their potential effects on the states, highlighted during the survey activities.

Pressure	Potential effects on states
G05.03 penetration/ disturbance below surface of the seabed	**Seagrass meadows**: the meadow coverage was about 70-75% on matte, with the presence of numerous inter-matte areas of sandy deposition. Several matte surfaces have been observed where marine seagrass has certainly retreated. The action of this pressure is considered scarce due to the limited presence of anchoring boats.
K03.03 introduction of disease (microbial pathogens)	***Pinna nobilis***: no alive bivalves were found. However, it could possibly related to the diffusion of the parasite *Haplosporidium pinnae* that is decimating the populations of the bivalve throughout the Mediterranean Sea.

4.5. A comparative discussion of the three site results

In this paragraph the main results (parameters/indicators) of the preliminary survey (WP 3 activity 1) carried out in the three project sites are compared and an overall assessment of the study areas is made together with a general analysis of data collected for activity 3.2. As mentioned before, some indicators are considered more than others as relevant in describing the ecosystem quality, so they are reported and discussed.

4.5.1. State description

Marine seagrasses general descriptors

General coverage of the wide area

In the Monfalcone site (Bay of Panzano) a high continuity of meadows (**90-100%**) of *Cymodocea nodosa* (and *Zostera* spp.) is observed in the monitoring stations and no particular signs of disturbance are recorded. However, other sites, coincident with the shallower areas, were little or no colonized. These areas probably presented some retreat dynamics (to be confirmed during the next investigations, as planned in the WP 3, Activity 3).

In the Kornati NP, on an overall view, P. *oceanica* meadows are widespread (**70-80%**), down to depths of 25-30 meters and with an irregular distribution that mainly follows the bathymetric pattern of the archipelag.

In the RNP Coastal Dunes site, the presence of *P. oceanica*, along the coast of the park, has been detected at a few hundred meters offshore. The meadow coverage was about 70-75% on matte with the presence of numerous inter-matte areas of sandy deposition.

In Kornati NP site and in RNP Coastal Dunes site, *P. oceanica* meadows can be considered widespread, presenting only limited areas devoid of seagrasses. These areas are characterized by 1) the presence of damage caused by anchor dragging (in Kornati NP) and 2) the presence of several surfaces of mattes (in RNP Coastal Dunes), where marine seagrass has certainly retreated, for reasons, as mentioned before, not directly connectable to anthropogenic pressure.

As an approximation, all three project sites well represent the conditions of their wide areas. Available data for the whole Brindisi littoral show that the remarkable linearity of the coast and of the seabed slope corresponds to a homogeneity in the distribution of marine seagrasses. Meadows regularly cover the entire coast, even with values of about 70%, but the mainly sandy bottom does not allow macrophytes to arrive nearshore and stop at about 6 meters deep.

These conditions do macth with a scarce use of the coast by boaters, who prefer more protected sites. Consequently, the eradication phenomenon of *P. oceanica* by anchoring is to be considered as modest on this site.

The situation in the other two sites is very different, where the two macrophytes (*P.oceanica* in Park Kornati and *C.nodosa* in Monfalcone) show high coverage. Distribution patterns in both sites respond to coastal morphology and bathymetric gradient, even if with significant different sedimentological characteristics, as we have seen. At bathymetries where pleasure boats prefer to anchor, the covers are extended in both cases. In Monfalcone, however much the data may have shown, the anchoring disturbances do not seem to irrecoverably damage the meadows, thanks to the strong seasonal colonization thrust of *C.nodosa*, which therefore manages to recover the degraded sections. At Park Kornati, the protected bays attract numerous boats and the damage from anchoring seems to originate a *P.oceanica* continuous retreat phenomenon that is very hard to recover due the longer time of *P. oceanica* recolonization.

Site coverage, shoot density and shoot length

In the Monfalcone (Bay of Panzano) site, for **percentage cover** and **shoots density**, limited differences along stations and zones were found, related to the presence of species (*C. nodosa* e *Zostera* spp.) characterized by different seasonal cycles (growth rate and spread, reproductive season, etc.). For **shoot length**, the differences are more evident and expected because of the different phenological cycles.

In the Kornati NP, differences in **percentage cover** and **shoot density** of *P. oceanica* were found along stations in the “Anchoring site” and in the “Diving site”. In the “Anchoring site”, coverage is very discontinuous and patchy, and these signs of disturbance are related to anchor dragging and scraping anchor chains along the seabed. Furthermore, this site, due to its morphology, bathymetric gradient, and exposure to the wind, behaves like a sedimentation basin (increase of siltation of seagrass leaves) thanks

also to the sediment resuspension due to pleasure boat traffic. Unlike the previous parameters, as concern the **shoot length**, the existence of differences along stations in the "Anchoring site" and in the "Diving site" resulted less evident.

In RNP Coastal Dunes site, for **percentage cover**, the data analysis suggests the existence of differences along stations between Zones 1 and 2 and Zone 3, because the stations placed in the Zone 1 and Zone 2 are characterized by values that are higher than the ones of the Zone 3. Unlike what was found for percentage cover, for **shoots density** and **shoot length**, the data analysis suggests the existence of limited differences along stations and Zones.

In summary, in the Monfalcone (Bay of Panzano) site, the differences found in the parameters' values are mainly related to the presence of different species (*C. nodosa* e *Zostera* spp.) characterized by different seasonal and phenological cycles. In Kornati NP site, these differences are related to the presence of two different areas, on *P. oceanica* meadows, where the stations where placed: the first one differs from the second one because the presence of anthropogenic pressure on the seagrass meadows (e.g., anchoring). In RNP Coastal Dunes site, the limited differences found seem related to natural reasons, such as different bathimetries.

Leaf lenght and width, leaf necrosis, No. of leaves and surface sediments

RNP Coastal Dunes showed a very different grain-size in comparison to Kornati and Monfalcone (Figure 21). Indeed, sediments were prevalently sandy with 92,7% of coarse sediment. In contrast, Kornati and Monfalcone showed approx. 70,8 and 73,3% of sand only. This depends on the morphological characteristics of the three areas. Monfalcone' is placed in the shallow bottoms of the Bay of Panzano, a relatively protected area. Similarly, Kornati is placed in a protected bay between the islands of the archipelago, while RNP Coastal Dunes is exposed to the influence of the open sea.

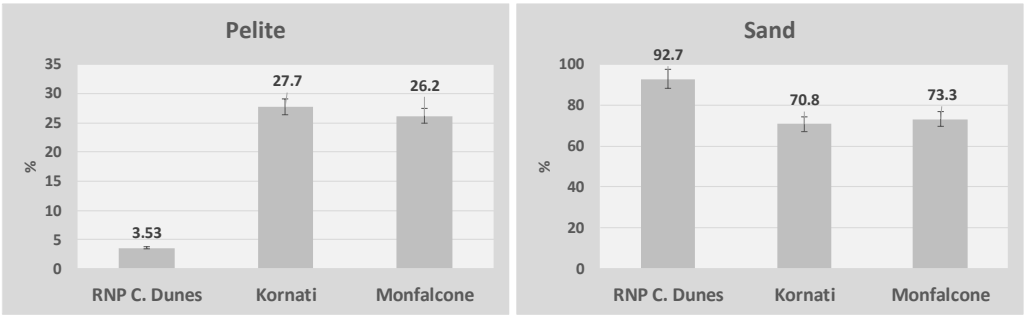

Figure 21. Sediment grain-sizes in the three study areas.

If we examined the concentrations of nutrients (Figure 22), on average Monfalcone differed from the other two areas resulting more eutrophicated with a lower Ctot amount and a higher Ntot and Porg concentration. This explains the absence of *P. oceanica* in this station, replaced by *C. nodosa* a species considered as a degradation facies of *P. oceanica* prairies.

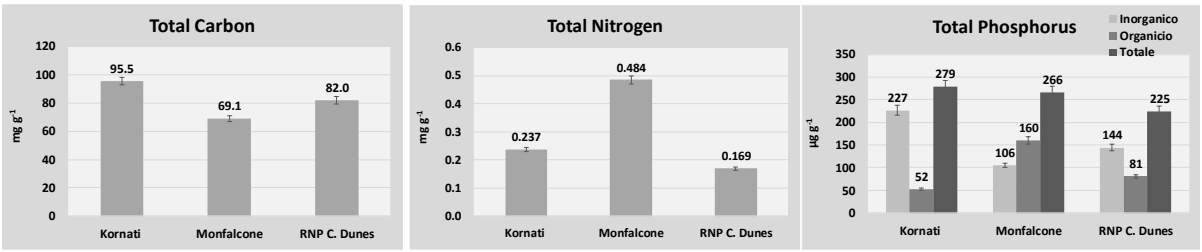

Figure 22. Concentrations of Total Carbon, Total Nitrogen and Total, Inorganic and Organic phosphorus in the three study areas.

		Seagrasses				Surface sediments				
		Shoot length	Shoot width	Leaves number	Leaf necrosis	Ctot	Ntot	Ptot	Porg	Sand
Seagrasses	Shoot width	0.67								
	Leaves number		0.73							
	Leaf necrosis			0.85						
Surface Sediments	Ctot		0.72	0.85	0.88					
	Ntot	-0.70			-0.77					
	Ptot									
	Porg			-0.86	-0.87	-0.77	0.70			
	Pinorg		0.70	0.85	0.78	0.77			-0.85	
	Sand							-0.79		
	Pelite							0.66		-0.93

In black p<0.05 per r ≥ |0.67|. In Red p<0.01 per r ≥ |0.81|

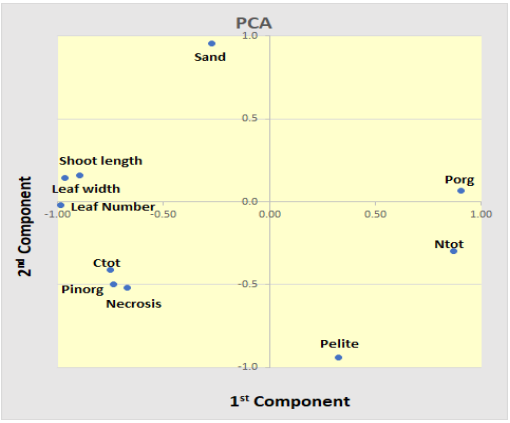

Figure 23. Spearman nan-parametric coefficients and PCA between environmental parameters and seagrass variables.

The non-parametric correlations showed significant positive coefficients of seagrass variables with the concentrations of Ctot and Pinorg and inverse trends with Porg and Ntot, whereas the sediment grain-size showed significant correlations only with Ptrot (Figure 23). Therefore, Ntot and Porg have a negative impact on seagrass growth and are not affected by the concentrations of Ctot and Pinorg.
The PCA analysis explained a total variance of 86,3% with two components only. However, the biplot confirms the relationship between the seagrass variables and the concentration of Ctot and Pinorg in surface sediments whereas they are in opposition to Ntot and Porg that increase the trophic levels of these areas.

Pinna nobilis presence (alive bivalves) and occurence of dead individuals

The limited number of alive individuals found in the monitoring areas (or in their proximity) in the Monfalcone site (Bay of Panzano) and in the kornati NP site can be related to the presence of the parasite *Haplosporidium pinnae* which is decimating the populations of the bivalve throughout the Mediterranean Sea. This parasite is widespread in the Northern Adriatic (Gulf of Trieste) and in south Croatia. Even the

absence of *Pinna nobilis* individuals (alive or dead) in the RNP National Park could be related to the potential diffusion of the parasite along all the Apulian coasts.

Table 15. Number of alive and dead Pinna nobilis individuals found during surveys (WP 3, Activity 1).

Pinna nobilis	Monfalcone (Bay of Panzano)	Kornati NP	RNP Coastal Dunes
No. of alive individuals	4	some individuals **in the proximity*** of the monitoring area ("Anchoring site")	0 (within the monitoring area or in the proximity*)
No. of dead individuals	0	1	0 (within the monitoring area or in the proximity*)

* *Pinna nobilis* density was measured counting all individuals encountered within a 1 m corridor for both sides of each of three transects 10 m long. Some alive (or dead) individuals were found only in the proximity of the monitoring corridor (outside).

Benthic communities

The data relating to phytobenthos and zoobenthos are limited to a general and qualitative description of the communities of the seagrass meadows in the three project sites. Therefore, these data are not comparable, considering how they are generalized and that relate to sites with different intrinsic characteristics and refer to different year periods (late spring for the Bay of Panzano (Monfalcone) and Kornati NP and late summer for RNP Coastal Dunes).

Water column

For the **Bay of Panzano (Monfalcone)**, and **RNP Coastal Dune**s, Reports on the Water Framework Directive monitoring results published by the Regional Agency for the Protection of the Environment show "Good Ecological Status". In the Report on the the Water Framework Directive River Basin Management Plans for **Croatia** (2nd RBMP), monitoring results show "Moderate (about 30% of water bodies) and Good (about 70% of water bodies) Ecological Status".

Regardig the "bathing waters" all the three areas have been classified as "excellent".

4.5.2. Main pressures

TRANSPORTATION AND SERVICE CORRIDORS

Concerning transportation, service corridors, marinas and yachting activities in the three project site, the highest number of boats (especially from July to August) is registered in the **Kornati NP**, where the majority of visitors comes with private / rented vessels. Also, the **Bay of Panzano (Monfalcone)**, an extremely shallow stretch of water, appears strongly frequented, in the summer period, even if the number of boats is lower than the average number registered in the Kornati NP. Contrary to what was found for the other these two sites, in the **RNP Coastal Dune**s site there are no relevant transport corridors and, despite the significant number of berths in the marinas, the analysis of the two available satellite photos (July 2017 and July 2018) shows a low frequentation of the area.

BIOLOGICAL RESOURCE USE OTHER THAN AGRICULTURE & FORESTRY

The data collected regarding biological resource use (such as suspension culture and leisure fishing) highlight, for the **Bay of Panzano (Monfalcone)**, the presence of only one large area dedicated to mussel and fish farming, small-scale artisanal fishing. In particular, considering the seagrasses, only 30 free-diving fishermen operate for a limited period on the meadows with no significant effect and a professional fisherman authorized to operate with cylinders limited to certain species of molluscs. For the **RNP Coastal Dunes**, in the analysed area that includes the marinas between Bari and Brindisi, the fishing fleet is more diversified than the one in the Bay of Panzano, ensuring versatility in fishing systems and variety in the fish species caught.

Contrary to what was reported for the other these two sites, in the **Kornati NP**, only artisanal fishing and recreational fishing are allowed and subjected to regulations on the type of fishing gear and maximum catch. However, some illegal fishing has been reported especially during bad weather, when there is no surveillance.

HUMAN INTRUSIONS AND DISTURBANCES

Regarding the human activities that cause disturbance in the project sites, in the **Bay of Panzano (Monfalcone)** they have been identified mainly among the sports activities such as diving, recreation, bathing with small boats and 61itesurfing activities, but this has no significant effect on seagrass meadows or habitats. The data collected showed that the diving activities, probably because of the shallow depths are very limited and attend the project area except in an extremely sporadic way. In the **RNP Coastal Dunes**, the human activities that cause disturbance are mainly among the nautical sports such as sky, diving and recreation or bathing with small boats. The area is not very known for diving but is well used by snorkelers while the diving activities, probably because of the shallow depdths are not usual. In the **Kornati NP**, snorkelling and swimming may only be done within swimming zones – a distance of up to 50 metres from the shoreline (except in strict protection zones).

POLLUTION

Regarding possible pollution in the **Bay of Panzano (Monfalcone)**, its causes are mainly determined by the increase in the flow of rivers, the runoff of agricultural areas, the venting of sewer overflows and the pipelines to the sea with their diffusers (Monfalcone port area, Staranzano purification plant). Furthermore, the presence of high winds from the south and high tide can prevent the normal mixing of fresh water with sea water, allowing the pollutant charge to remain.

In the **Kornati NP**, the most critical pollution phenomena are attributable to domestic wastewaters. Another issue is the accumulation of marine litters because of the presence of numerous pleasure boats (and small tourist settlements); however, in the park, the increasing garbage collection practice (on the water and on land along the shore) is limiting the problem.

In the **RNP Coastal Dunes** site, possible pollution causes are due to human activities that contribute to the emission of nutrients and compounds to the marine environment.

INVASIVE, OTHER PROBLEMATIC SPECIES AND GENES

In the three study sites, during the surveys activities no alien species were found, even in Kornati NP site, where the marine invasive species *Caulerpa cylindracea* and *Womersleyella setacea* have been observed in the last years and are spreading in the entire Park.

However, in the RNP Coastal Dunes study area, it is important to emphasize the abundant presence of *Caulerpa prolifera* (a "green alga"), an indigenous species related to the dangerous *Caulerpa taxifolia* and *Caulerpa cylindracea* which are invading some areas of the Mediterranean. In fact, regressed meadows are prone to invasion by one or more of the potential substitutes for *P. oceanica* such as this algal species (in particular, *C. cylindracea*) or the other common Mediterranean seagrass *Cymodocea nodosa*.

4.5.3. Main impacts

Kornati NP

In the **Kornati NP**, some illegal fishing has been reported especially during bad weather, when there is no surveillance. Furthermore, in the park there are two easily identifiable types of sites:

- a wide part of the park where the depth of the seabed increases rapidly and the exposure to winds does not allow anchoring. In these areas, the seabed and the segrass meadows are in excellent natural conditions;
- numerous sheltered sites where anchorage actions cause significant impact that include eradication of segrasses and consequent degradation and loss of species and habitats.

RNP Coastal Dunes

In the **RNP Coastal Dune**s, there is not a dense pleasure boat traffic and, despite the significant number of berths in the marinas, the analysis of the two available satellite photos (July 2017 and July 2018) shows a low frequentation of the area.

The difficulties in quantifying the different potential pressures did not allow us to identify precise relationships with their real impacts. This is confirmed by the observations carried out in field and the information acquired that significantly suggests that marine seagrass rarefaction due to summer anchoring boats on the meadows is a negligible impact on this site.

Bay of Panzano (Monfalcone)

The conditions observed for the Bay of Panzano (Monfalcone) conserning seagras meadows show that although anchoring boats are numerous in summertime, their impact is scarce. The presence of fine-medium sediments that dominate this environment and the agricultural areas runoff in the rivers contribute to a condition of relative turbidity which limits the distribution of *Cymodocea* in deeper areas. However, the species of this site easily withstand high levels of sedimentation and resuspension. Unlike the slow growth dynamics of *P.oceanica*, present in the other two sites, *C.nodosa* here is able to well recover any rarefaction phenomena that occurr due to direct physical causes, thanks to its strong branching capacity.

In general, exluded some specific sites, the impacts from impacts from yachting and fishing traffic on the colonized shallows are in fact modest on low-medium entity, both as direct (physical) and indirect (suspended and embedded sediments) actions.

4.5.4. Responses

Kornati NP

The analysis of the previous pages leads to confirm the hypothesis of the strong significant correlation between high presence and traffic of pleasure boats on the one hand and physical disturbance towards marine seagrasses on the other. The Park Kornati highlights the greatest suffering, in this sense, given that the coastline is very jagged, and the yachting offer is aimed at a huge number of boats that sail and anchor for the night in the numerous bays and shelters of the archipelago. As a result, there is a large use of anchoring on *P. oceanica* habitats, which are repeated every day and several times a day for the entire summer season.

This condition and the consequent impacts have already been raised at the park management level, which highlights the difficulties in addressing the public management policy on these aspects when concerning the entire Croatian coast and the lack of means to challenge the problem of anchoring on seagrasses and of balancing touristic use and resources conservation.

The main answers that are considered adequate for this objective and on which the park intends to work consist primarily of the definition of marine seagrasses resources. The meadows distribution data are in fact only very roughly defined to date, but they are necessary to direct the safeguard measures of the plants, especially in the most favored bays for recreational use.

A more precise identification of the marine seagrass coverage and of its possible retreat dynamic (by the means of a dedicated **monitoring**) is necessary because of the different behavior of some areas, still preserved and intact and of others where human activity has already made an evident impact and has consequently contributed to changes of the environment. Some pilot studies show in fact that the areas closer to marinas and small villages are more likely to be under the influence of anthropogenic pollution, yet areas that are more distant remain anthropogenically unaltered. To extrapolate these results to the entire Park, a first necessary action consists in a deeper knowledge of the marine seagrass distribution, related to an analysis of short time dynamics, preferably together with the dissolved and particulate load of the seawater.

Therefore, it is advisable to push with the installation of adequate wastewater treatment plants; in recent research (Ilenič *et al*., 2018), the necessity of the installation of these treatment plants in protected areas such as the Kornati NP is highlighted.

On the contrary, the diving activities management is already well arranged (autonomous diving is allowed only in organized groups and requires a license) and professional fishing is forbidden.

RNP Costal Dunes

The problem of anchorage disturbance, as seen, occurs only in some areas and not along the entire coast of the park. Management is mainly focused on the problem of coastal erosion and the defense of the fringe slope. For this, the Apulia Region carries on **planning instruments** and, in particular, released a Hydrogeological plan, aimed at recovering the loss of biodiversity and of ecosystem services, for example through the protection and nourishment of the beaches. Similar purposes were indicated in the SCI "Litorale brindisino" (IT 9140002) management plan (2009), the content of which was partly updated in the RNP Coastal Dunes territorial plan (2013).

Regarding the problem of water pollution, the "Water Protection Plan" (PTA) is a dynamic tool of knowledge and planning, which aim to the integrated protection - in a qualitative and quantitative way - of water resources, in order to pursue a healthy and sustainable use of the coastal zone, including indications for mollusks cultivation. Furthermore, the presence of wastewater treatment plants contributes to the reuse of treated wastewater otherwise discharged for discharge to the sea.

Bay of Panzano (Monfalcone)

The general good quality and vitality of the seagrass populations in the Bay of Panzano and the relatively low anchoring boat impacts (except for some specific points) indicate, however, the need to take measures for the protection of the seagrass meadows against yachting anchors. For the moment, this need appears less urgent than what was pointed out for Kornati NP, regarding the anchoring pressure.

The possibility of implementing specific fishing regulation and preventing disturbance to marine seagrasses often clashes with illegal trawling practices. In this sense, the establishment of protected areas and their control are often a winning weapon, in favor of the sea bottom communities and fish fauna that benefits from them.

On a general overview, the possible measures addressed to the recovery of the endangered marine seagrasses system, as differently observed in our sites, start from the need for a dedicated **monitoring plan**. In fact, the management of monitoring, as provided for in the Habitats Directive, WFD and local management plans, often sees the marine seagrasses component neglected, even if only for the difficulties that underwater operations pose.

A more responsible **management of the accesses and anchors** is fundamental and constitute the core of the WP5 analysis carried on in SASPAS.

SASPAS intends to experiment an approach that integrates concrete actions to offer ecological moorings with information disseminated to all public managers, operators, and users of the touristic sector. The aim is to develop a more advanced and conscious awareness of the ecosystemic offer that the habitat at marine seagrasses offers to the whole coastal zone.

5. CONCLUSIONS

The objective of the WP3 Activity 2 – here reported - was to combine the information collected in WP3 Activity 1 during the preliminary survey with the available data collected on the environmental quality status of the sites and in particular of the current marine seagrass populations; this resulting mass of information was therefore analyzed in the light of the main existing pressures.

The aim was to interpret the consequent most significant impacts affecting these valuable habitats on the various sites to better target their conservation and management. All of this with the aim, which will be rose again in WP 5, to focus the possible corrective measures against pressures acting directly, such as disturbances produced by pleasure or fishing boats, more than indirect pressures such as turbidity and pollution caused by more remote waste outflows or traffic.

We began with a working hypothesis according to which the marine seagrass populations could have different types of impact in relation to the type of sites, the existing anthropic pressures, and the tourism development. The main pressure considered was the pleasure boat anchoring, producing impacts that include eradication of macrophytes, consequent degradation and loss of species and habitats, ultimately resulting in the deterioration of their conservation status.

Thanks to the field work carried out in WP3 Activity 1 and by the collection of available data we attempted a quantification and analysis of these impacts, trying to link them, with a conceptual approach, to the highlighted pressures to confirm the initial work hypothesis.

The work favored the analysis of states and pressures, with the idea of limiting attention mainly to these components, given the experimental characteristic and the concreteness of the actions envisaged. We substantially confirm the working hypothesis according to which the sites are thoroughly different in terms of sedimentological and morphological aspects and of seagrass meadows distribution patterns. These differences can represent a model, as far as possible, of the diversity we can find in the Adriatic area, where we can approximately highlight the following types of coasts, according to the environmental vocation for marine seagrasses presence and on the basis of what has been analyzed so far:

- North Adriatic sector, characterized by low and linear coast, by sediments with a scarce or fine sandy component, turbidity in the water column, little or no presence of marine seagrasses except in the sections that have bays and coast shelters with a morphology that maintains characteristics of naturalness, with *Cymodocea nodosa* and *Zostera marina*; strong anthropogenic pressure and widespread modifications to the coastal profiles;
- Eastern Adriatic sector, with rocky coasts, coarse seabed sediments, poor turbidity and low resuspension rate in the water column, widespread marine seagrasses (especially *Posidonia oceanica*) increasing southwards, thanks to the strongly jagged coastal conformation and the scarce anthropization, restricted to punctual stretches of the coast; strong tourist pressure, along the continental coast and in the numerous archipelagos;
- Western Adriatic sector, with low and linear coasts with fine sediments, which progressively, even if irregularly, become higher coast with coarse sediments, especially in the Apulian tract which

has extensive *Posidonia oceanica* meadows; strong seaside tourist pressure, with nautical tourism not particularly developed due to the linear and exposed coast and the absence of islands and archipelagos.

This categorization can only be approximate and is of course completely instrumental in identifying the elements that characterize marine seagrass meadows and the inclination for nautical tourism, potentially impacting. As can be seen from the list, the three types of sites are very different from one another under this light and especially as for the tourist user base that revolves around them.

The first sector represents the standard condition of the Bay of Panzano (Monfalcone), where the coastal conformation and a large marine area of tidal flats and shallow waters are characterized by remarkable naturalness and maintain high topo-bathymetric variability. These conditions result in the stability of extensive meadows of *Cymodocea nodosa*, species with a marked seasonality and with a strong underground hypogean component. The Bay offers reason for anchoring and sheltering a fleet of smaller pleasure boats that anchor on 1-3 meters of seabed to spend the day at sea.

Despite the numbers, this pressure does not seem to lead to significant impacts on the meadows. We believe this is mainly due a) to the strong branching and recolonization efficiency of the macrophyte after the eradication events and b) to the lack of use of chain catenaries, considering the modest size of the boats.

The second sector, well represented by the site of the National Park of Kornati, consists of the coast that descends from Istria to Dalmatia, which offers a coastal landscape second to few in the world, with rocky coast, rocky or pebbles beaches and rocky or coarse sandy bottom. River inputs are scarce or absent at all and the water column is clear as we proceed along the coast southward. With the same trend, we find Posidonia oceanica meadows increasingly extensive and in good condition, only locally disturbed along the mainland coast in the most urbanized and touristic sites. The coast in fact attracts an impressive tourist flow that includes a large fleet of pleasure boats that anchor for the night in the various bays with numerous days of stay. This also occurs especially in the Park, where until now the protection policies do not include concrete attention for the *P. oceanica* habitat.

We found that the conditions of *P. oceanica* populations in the Park are good, except for the numerous bays where the pleasure boats drop anchor. The average size of these boats, the frequent use of chain catenary, the spillages, and the sewer result in a strong disturbance against the meadows which show retreats estimated over 50%.

The third sector, on the western Adriatic shore, includes a long coastline which has mainly straight, sandy, and rocky stretches, all characterized by considerable tourist pressure, but little pleasure boat traffic interested in anchoring along the coast, such as our collected data highlighted. Only along some parts of southern Apulia does the coast, rocky and jagged, attract a nautical tourism of a certain relevance which can result in disturbance to *P. oceanica* which here often comes to colonize the bottom almost up to the shoreline, like in the Dalmatian coast.

The coast of Ostuni shows largely a linear seashore, subjected to a general phenomenon of retreat due to frontal erosion. The *P. oceanica* meadows are widely present a few hundred meters further off and begin at a depth of about 8 meters, as they cannot colonize the incoherent sea bottom further to the shore, which is more exposed to bad weather - marine adverse events.

For these reasons, marine seagrasses coverages present only limited disturbances attributable to yacht anchoring, which occurs closer to the shore, on a unvegetated sea floor. Fishing represents a very limited disturbance as well. We believe the site examined, along the Brindisi coast of Ostuni, therefore represents, in the context of the Project, an intermediate situation, in term of anchorage disturbance, between what was detected in Monfalcone and what was detected in the Park Kornati.

This analysis shows that there are quite different realities in terms of pleasure yachting and of density of anchorings in the investigated sites of Adriatic coasts and that the impacts on marine seagrasses come from numerous directions. On the basis of the data and information collected and of a conceptual analysis, it is clear that only in some coastal environments the anchorage disturbance causes significant and lasting impacts. This plurality of phenomenologies must be considered together with the possible answers in terms of coastal resource management, in the context of the work of WP 5.2, concerning the “Definition of the Marine Seagrass Safeguard Integrated Management Program (MSSIMP)”.

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7. ANNEXES

Data have been collected and harmonized according to the project framework and the DPSIR categories. All the data collected in several files will be compressed into zip folders will be avalaible on the GIS platform planned in WP 5, activity 1:

Panzano_marine_culture.zip

Panzano_free_dive.zip

Panzano_diving.zip

Panzano_anchoring.zip

Panzano_boats.zip

Panzano_artificial.zip

Panzano_arpa.zip

Dune_artificial.zip

Dune_boats.zip

Dune_anchoring.zip

Dune_diving.zip

Dune_arpa.zip

Regarding the KORNATI NP, alle the quantitative and descriptive data have been provided directly by the park managers (http://www.np-kornati.hr/en) and/or reported in literature (Casier R., 2011; Mihelcic and Ramov, 2018; Ilenič *et al.*, 2018; Ivković N., 2015).